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# TRAFFIC QUARTERLY

AN INDEPENDENT JOURNAL FOR BETTER TRAFFIC

OCTOBER 1961

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Safety
Seeing Habits and Vision
The Future of Toll Roads
Streets for the Urban Traveler
Function of the Insurance Institute
A Look Ahead at Highway Programs
Highway Events and Driver Actions
Land Use at Freeway Interchanges
Human Factors in Highway Safety
Effective Traffic Court Penalties
Use and Misuse of Traffic Signs
New Rapid Transit Planning

THE ENO FOUNDATION FOR HIGHWAY TRAFFIC CONTROL

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# Traffic Quarterly

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# Safety

Our driving regulations are frequently oversimplified as "Keep to the Right" and "Do Not Speed." Notwithstanding all efforts to post warning and caution signs, they appear inadequate and insufficient as effective controls of present-day drivers. To the most casual observer, they are wilfully ignored.

Possibly the many incentives to go by car overcome sane provisions to travel safely. Obviously no effort has been spared to build safety into our highways. The highway engineer cannot build caution or safety into the minds of unqualified drivers or wilfull speeders.

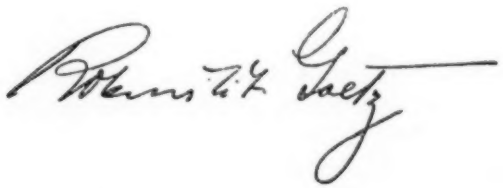
With present records of licensing among the fifty states, it is difficult to place them in categories that would be helpful in improving our licensing systems. Some improvement in the national character of our driving is urgently needed.

So long as many of our licensed drivers wilfully seek opportunities to evade the well-posted laws of the road, we may continue to expect little improvement in our driving. This is not the fault of the police—they have a monumental task. The police have been forced to resort to many forms of apprehension of the unlawful driver but cannot successfully compete with the habitual violator.

We urgently need improved laws for licensing and revocation.

We are in the midst of a great national project to increase and improve our present highway system. Undoubtedly this will mean more cars, more drivers and increased mileage. It seems appropriate at this propitious time that all states join in a determined effort to improve our licensing measures, improve our driving controls and lower our accident and death rates. Undoubtedly it would receive public approbation.

Our present driving record is a matter of grave national concern.



# A Look Ahead at Highway Programs

REX M. WHITTON

*Mr. Whitton, long a highway official, has been Federal Highway Administrator since February 10, 1961. He heads the Bureau of Public Roads, United States Department of Commerce, and has direct responsibility for administering the federal-aid highway program. Included in the program is the 41,000-mile national system of interstate and defense highways and hundreds of thousands of miles of primary and secondary roads and their urban extensions. Previously Mr. Whitton was Chief Engineer of the Missouri State Highway Commission when he resigned after more than forty years of service with the highway department. He was named a member of the Executive Committee of the American Association of State Highway Officials May 1, 1954, and reappointed in 1957. He served as president of the American Association of State Highway Officials in 1956. He is a past chairman and presently a member of the Executive Committee of the Highway Research Board; recipient of the George S. Bartlett Award in 1958 for outstanding service in highway progress in the nation; selected by the American Public Works Association as one of the Top Ten Public Works Men of the Year in 1960.*

LOOKING ahead is an exhilarating exercise, but one that often brings scorn on the oracle. If he looks forward to a slightly modified present, he risks being called a visionless plodder. If he looks far into the future, foreseeing radical changes from the present, he is likely to be called an ivory-tower dreamer.

So, how far shall we look ahead at the highway program? Perhaps the title itself suggests a reasonable answer—no farther into the future than we may expect to have highways to carry vehicles operated by their individual owners at times of their own free choice, and between origins and destinations and for purposes of their choice. It is the opinion of many well-informed persons that this limitation covers a good many years ahead. Of course, it also pretty well defines the present.

My concept, then, is that for as far ahead as I care to look, people will want highway transportation of about the same basic nature as they now have. By this, however, I do not mean that highway and vehicle design will not progress. Within our own lifetime,

we may see some highway sections, and some vehicles, radically different from those now familiar to us.

But we obviously cannot expect that the three and one-half million miles of roads and streets and the seventy-four million motor vehicles we have today are suddenly, or over a short period of time, going to be abandoned for something completely new and different. Even if the world were at peace, and our only problems were internal ones, any change in our transportation system would have to come rather gradually; else our national economy might well stagger in the turbulence of the change.

One more philosophical point. Right now men have the vision (although their visions are varied and often conflicting) and the technological capacity to redesign completely the highway and the vehicle. The possibilities of improvement might well be considered almost limitless. But the highway and the vehicle are only two elements in the highway transportation system; the third element of the system, equally essential, is the driver. Can we radically redesign him?

Let's take a far-fetched example. Give the highway and automotive engineers and their industries, let us say, ten years and ten trillion dollars. I'm sure they could produce a whole new highway network and fleet of vehicles with capacity for 500-mile-an-hour sustained speed. But in that decade, or in centuries for that matter, can we breed a new race of human beings with the physical capabilities, such as perception and reaction times, adapted to such a speed?

It is a logical consequence, in this age of automation, to say: Why not automate the highway and the vehicle? This, too, is technologically possible, although again the price tag will be high and the change-over fraught with complexity.

But what proportion of our population are rugged individualists, who *want* to drive their own vehicles? And is automated travel economically sensible for short trips—which comprise the bulk of our total travel? And what about the transition period? Nevertheless, vehicle guidance and control loom as a likely prospect of the future. More of that later.

It seems reasonable to suppose that our three and one-half-million-mile road and street network will not expand greatly in

length in the years to come. Some three-quarters of the interstate system is being built on new location; but even so, these 30,000 miles of new freeways will represent an increase of less than one percent in our total mileage. I think we can expect that even before the interstate system is completed, in 1972, the public itself will demand more of the same. We certainly want to get this job done first, of course. But by the 1980's it may well be that another 5,000 or 10,000 miles of freeway will be needed.

### THE DEMAND AHEAD

I think we can also look for a fairly sizable increase in mileage from quite a different motivating force—the tremendous growth of suburban population has and will continue to spur new residential developments, each with its requirement for an access and service street network.

Though we do not seem to need any great proportional increase in quantity of mileage, the same can certainly not be said for quality. Much of our road and street network needs improvement that will make for smoother, safer, faster riding. By the latter I do not mean excessive speed, but reasonable *sustained* speed, without irritating, time-consuming slowdowns at steep hills, sharp curves, narrow bridges, etc.

While we will not need increased quantity as measured in miles, we certainly will need vastly increased quantity as measured in terms of highway capacity. We are going to have a lot more travel to take care of.

Estimates made by the state highway departments in cooperation with the bureau of public roads indicate that by 1976 the United States may have a population of 230 million, twenty-eight percent more than now; and 113 million motor vehicles, an increase of fifty-two percent. Those vehicles will travel 1.2 trillion miles in 1976, a gain of two-thirds over the present total annual travel.

The usage of highways can be made to seem deceptively little. On the average, at present, there are only twenty-one vehicles for each mile of road and street. Even by 1976 the average will still be only thirty-two. But traffic is not distributed by averages. The interstate system, comprising little more than one percent of our total

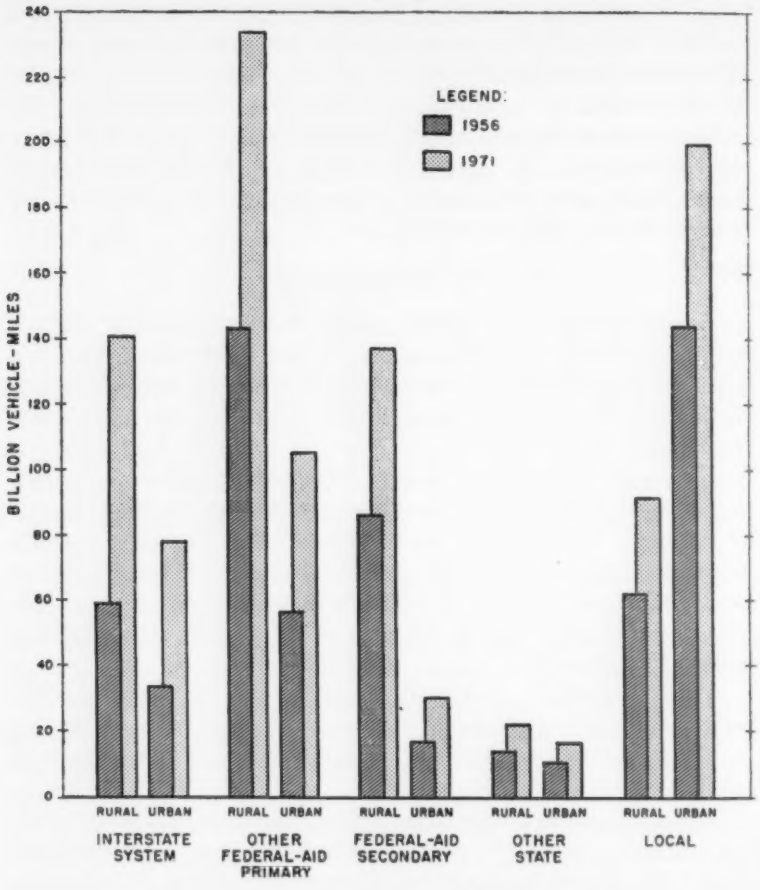



Figure 1. Highway Travel (1956 and 1971).

mileage, will carry more than twenty percent of all traffic when it is completed. Urban streets and thoroughfares, only one-tenth of the total United States mileage, account for over two-fifths of the traffic now.

An indication of where we stand is shown by an estimate developed by the Bureau of Public Roads (necessarily involving a number of assumptions) of the usage of the federal-aid primary highway

system. The rural mileage of the system is operating at sixty-four percent of its practical capacity, which is not a particularly critical position (although capacity by itself is not a full measure of satisfactory service). But the urban mileage is now operating at ninety percent of its practical capacity, an indication of trouble not too far ahead. Parenthetically, I doubt that many drivers today need statistical evidence to convince them that congestion exists on our main arterials. A great many of them see it themselves, every day.

To show the great variation in traffic distribution, Figure 1 portrays the estimated annual travel in 1956 and in 1971 on the several highway systems. The spectacular increase anticipated for the interstate system is quite evident. Perhaps no better comparison of the distribution of travel can be made than that shown in Figure 2, portraying average daily traffic on the same systems represented in Figure 1.

## THE FEDERAL-AID PROGRAM

President Kennedy succinctly stated the need to look ahead—and to match vision with action—in his message on highways to the Congress early this year. He said: "I am wholly opposed to either stretching out or cutting back our highway program . . . to postpone completion of the interstate system only further postpones the day when our highways will be adequate to meet our defense, economic, and general population increase needs."

While the financing program recommended by the President was not adopted in all its details, the legislation enacted and approved on June 29, 1961 does meet the essence of the President's objectives.

Completion of the 41,000-mile national system of interstate and defense highways by 1972 is now assured. And federal-aid funds approaching $1 billion annually will be available for continued large-scale improvement of the more than 800,000 miles of major rural routes, urban arterials, and feeder roads on the federal-aid primary and secondary systems and their urban extensions (the so-called ABC program).

While the federal-aid highway act of 1961 has resolved the financing problems of the federal-aid program for the next decade, many of the states still have heavy financing problems ahead. Since

the federal-aid matching for the interstate system is ninety percent federal, ten percent state, and for the ABC program it is fifty-fifty, the states must provide well over $1 billion a year during the next decade for financing federal-aid highway construction alone.

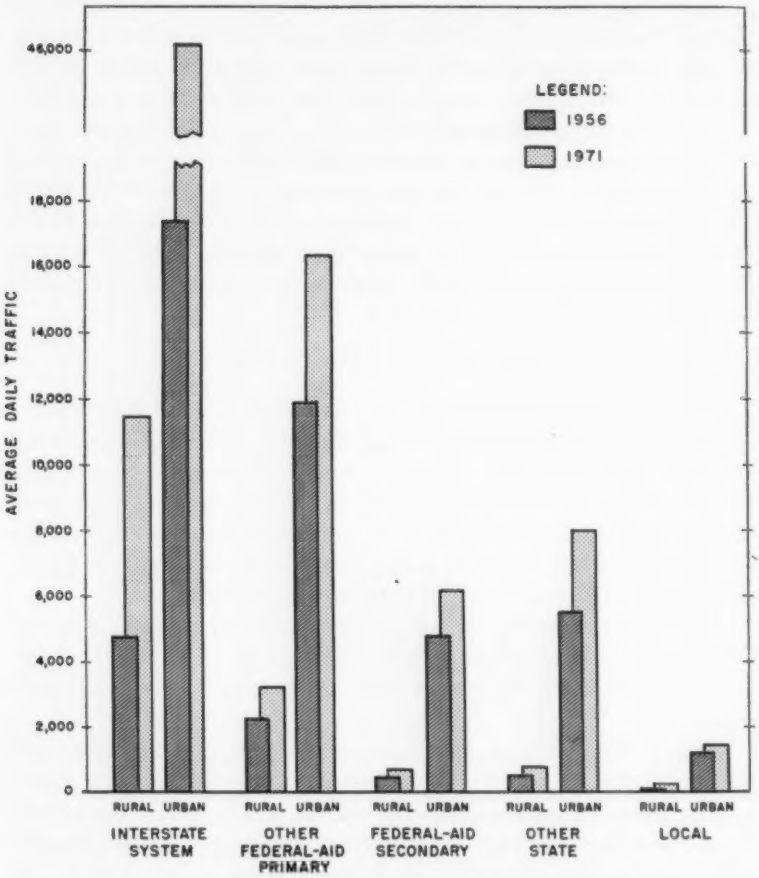



Figure 2. Average Daily Traffic (1956 and 1971).

In addition, the states have the entire financial responsibility for operation, maintenance, and administration of their highway systems. They also certainly want to undertake at least some construction over and above that financed with federal aid.

Careful studies of needs, and development of comprehensive long-range programs, are a must, if the tremendous highway expenditures of the future are to be wisely made. Of equal importance is the study and planning of financing for such programs, with levies for revenues equitably distributed among the various classes of highway users and others who may benefit from them.

### HIGHWAY FINANCING

Many states have already made such studies. The four-year highway cost allocation study recently completed by the Bureau of Public Roads will be of inestimable value to the states, both as a model for such undertakings and as a source of background and factual material.

Such studies are next to worthless, of course, unless they result in adopted legislation and improvement programs. For such ends, informed public support is imperative. Any public works program necessarily is forged under the heat of controversy and the hammers of groups with diverging interests, and the anvil of public opinion has much to do with the shape of the results.

Public support for highway financing will be engendered, perhaps more than by any other factor, by the experience of driving on modern highways.

One facet of highway financing on which the public might well be better informed is the cost of owning and operating our highway systems. I am sure the average citizen has uneasy reactions to the frequent announcement of individual interstate projects costing half a million or a million dollars, or more, per mile. Yet these are the projects that will carry tremendous volumes of traffic. They are literally the cheapest, not the most expensive, per vehicle-mile of travel.

This is well demonstrated by the calculations illustrated in figure 3. The cost of owning and operating all roads and streets in 1975, on the average, will be nearly one cent a vehicle-mile, with rural sections running about a tenth of a cent more, urban sections nearly three-tenths of a cent less.

But for the interstate system, the cost is less than one-half cent; in contrast, the generally low-travel non-federal-aid rural roads cost nearly two and one-half cents per vehicle-mile. The heavily

traveled highways, despite their high construction cost, earn their cost to a far greater extent than the lightly traveled roads. The former indeed pay for the latter.

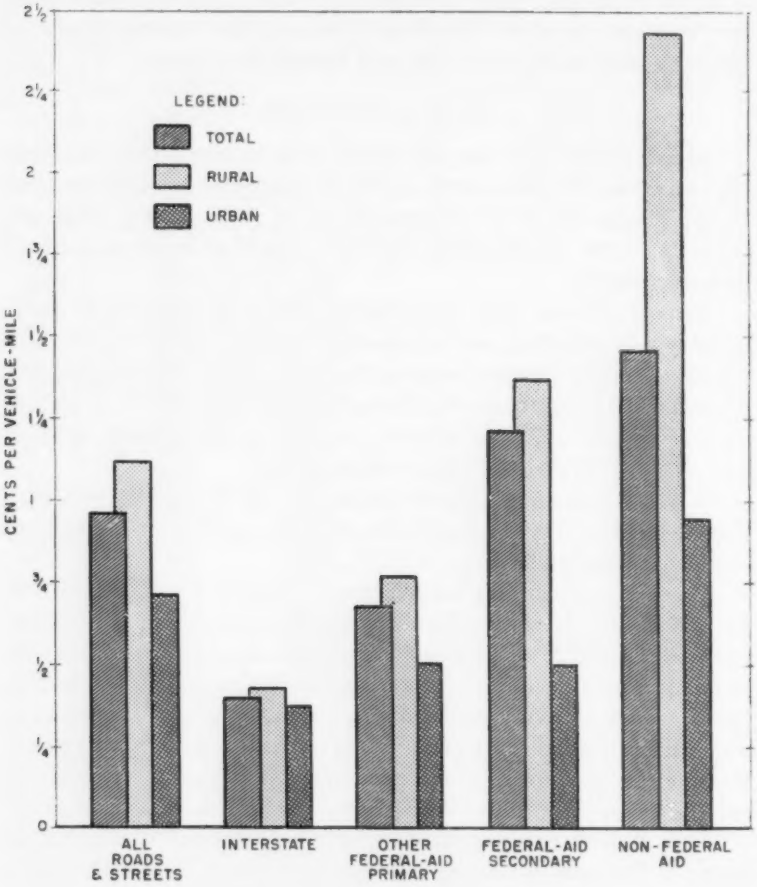



Figure 3. Highway Cost per Vehicle-mile (1975).

Nowhere are our transportation problems greater than in our urban areas, especially in the larger cities and the great metropolitan areas. The subject has been widely discussed during recent years, and there is by no means universal agreement on solutions

at the present time. However, highway planners and city planners have made giant strides toward better understanding, and in city after city have successfully and effectively worked in close cooperation.

### URBAN PROBLEMS

I think each discipline has learned much from the other in the last few years. The highway engineers are justly proud of their contributions to the planning process, through such research as the study of the relation between vehicle travel and land use, for example. Highway engineers recognize that they are not city planners, and that the forecasting, planning, and regulation of land use is not their assignment.

Where we have entered into the field in the past, in some cases, it was because others had not, and the work was necessary if highway planning were not to remain at a complete standstill. But in a paper whose subject is looking ahead, a discussion of the past and the present is not germane.

To look ahead toward solutions of the urban transportation problem, at the present time, requires a genuine prophet; and I am reluctant to lose my honor in my own country. There are widely divergent views among city planners as to what form or shape the metropolis of the future should take.

Whatever the choice, and it is not unreasonable to suppose that there is no single best choice, transportation planning must be fitted to the city plan. Conversely, and equally important, no city plan will be workable if transportation cannot be adapted to it, in full practical measure.

Perhaps as important as any other facet of the urban transportation problem is that of parking. There must be, in the years immediately ahead, a vigorous attack on this problem. The trend is not defined by the past, nor need it be. In all probability, municipal and private efforts, and combinations of them, all are needed.

A significant key to the future of urban development may well be the federal legislation recently enacted, giving to the housing and home finance agency the authority and the funds to assist the cities and states in urban and regional planning, including transportation planning. The work of the HHFA in these fields cannot

fail to be of important influence, and will be watched with keen interest.

Once in awhile all of us, I think, need to remind ourselves that the ultimate objective of our planning is to benefit the people. Suffice it to say that ultimately it is they who decide what they want for themselves, and are willing to pay for. Like planners, they too do not all think alike. While one may prefer the high-rise apartment and transit, another likes his suburban home and car. To

Figure 4. Only 30 Percent Goes to Heart of City.

paraphrase the old saying, one man's treat is another man's aversion. People fit no common mold, nor can they readily be molded contrary to their own desires.

### ROAD BUILDING TECHNOLOGY

There are strong indications that their current needs and desires involve a considerable scatter of movement, as results of urban studies show. In our large urban areas, less than one-third of all traffic approaching the city is destined for the downtown core, as shown in Figure 4. And within the city itself, less than half of the total daily personal trips are in the fixed-pattern home-to-work movement, as shown in Figure 5.

Traffic on the AASHO road test in Illinois came to an end last fall, and analysis of the countless bits of data is proceeding apace.

While this research project is not likely to revolutionize structural design overnight, or to prove that under all circumstances one kind of pavement is wholly superior to another, undoubtedly the results will be of great significance.

I look forward during the next few years to the next logical step, a number of so-called satellite tests which, on a much smaller scale, will check and expand the AASHO test findings on a variety of soils and in a variety of climates, across the country.

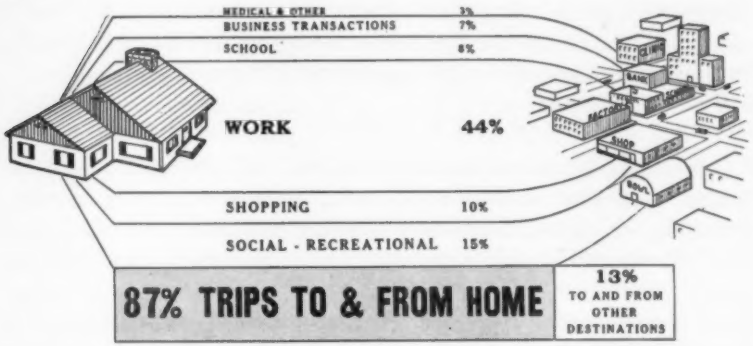



Figure 5. Within a Typical City of 1,000,000 Population 1,200,000 Trips Made Daily

The AASHO test, together with these satellite tests, should go far toward making highway pavement design a real science, in which opinion and judgment will have little or no place. Beyond the sound empirical design methods that can be expected to be developed within a few years, the test results should have a much greater effect in the long run.

The vast quantity of factual information recorded should, for the researchers, be the grist that ultimately will lead to rational theories of design which will in turn lead to more durable and at the same time more economical pavements.

We need, and should expect, too, fruitful basic research into the nature of soils and of asphalts. A full understanding of them is essential for their more efficient control and use. Continued study of the use of chemical additives for the improvement of poor road-base

soils is another promising field. A real miracle find is not too probable, but really useful chemicals may yet be found for this purpose.

It is unlikely that any entirely new and revolutionary basic materials for road building will be discovered in the foreseeable future until, eventually, safe means of using atomic heat and energy can be developed. Then, perhaps, we can merely level the ground, whatever its nature, and fuse it into an enduring rock pavement.

That prospect appears to be not too immediate, however. In the meantime we may expect to continue to use Portland cement and asphalt, but undoubtedly we shall improve them both. We will also continue to use the same types of aggregates that we do now, but we must find ways to use aggregates of poorer quality.

### ELECTRONIC VEHICLE GUIDANCE AND CONTROL

We have already had some revolutions in road-building equipment, over the years—earth-moving equipment being an outstanding example. Guided road-building equipment, automatically leveled by sensing devices controlled by wires or light beams, seems destined to come into common usage. But again, in the years immediately ahead it is likely we will see refinements—some quite remarkable, perhaps—rather than radical innovations in road-building equipment.

One of the strongest attractions of interest in discussions of the future of our highways is the subject of electronic vehicle guidance and control. The Sunday supplements in recent years have given us breath-taking visions of high-speed cross-country motoring, with the automobile occupants happily playing bridge; or the business man hopping into his car at home, pushing a button, and then reading the newspaper while the automatic pilot safely steers him downtown and into the reserved stall at his parking garage.

### TRAFFIC AND HIGHWAY CONTROL SYSTEMS

The electronic hardware for such potentials, and others, have not yet been fully developed, but I have not the slightest doubt that they can and will be. There are actually two different general courses involved in the future use of electronics on highways: one is in traffic and highway control systems; the other in vehicle guidance and control systems.

Electronic traffic surveillance, for traffic control, is already under test in Detroit, where strategically placed television cameras, remotely controlled, feed continuous detailed pictures of traffic along a three-mile freeway into a central monitor station.

The operators of such a surveillance system, constantly watching the changing traffic patterns, will be able to actuate signs at entrance or exit ramps, admitting or barring entering or leaving traffic as necessary. By radio or telephone they will be able to dispatch police, fire, or towing vehicles in the event of an accident or traffic tie-up. Such operations offer much promise for heavy-traffic freeways.

Communication from the highway to the driver has already been developed experimentally or at least in theory in a variety of ways. The simplest form, already in use, is the remotely controlled valuable-message sign, warning of fog or snow and reduction in speed in accordance. Another form already developed experimentally is induction radio broadcast from alongside the roadway with just enough range to carry a message to the car radios of vehicles passing by.

Communication between drivers of vehicles is another field being explored. Here, the communication does not, of course, mean the ability for one driver to talk to another—I suspect if this were practical, most messages would be entirely unquotable.

At present, the only inter-driver communications we have are the brake tail-light and the turn signal; both red and both often working from the same lens. We are sadly lacking in this field. Only recently the interstate commerce commission required that commercial vehicles under its regulation must have a switch that will simultaneously flash *both* turn signals, to indicate that the vehicle is standing still.

We need to develop signal devices by which one driver may signal to another, with complete clarity and no possible misinterpretation, that he is going to turn, stop, slow down, or accelerate; and perhaps his speed. Radar or infra-red devices might be used to warn by visual or audible signal to a driver that another vehicle is close ahead, behind, or alongside.

The common traffic signal itself has long since moved into the electronic field. We already have, in some cities, complex traffic

control systems in which traffic sensors count the vehicles and relay the information to a central control station where computers assimilate it and feed instructions by radio back to the traffic signals.

These systems, as fantastic as they would seem to the old-time policeman standing under his umbrella in the street intersection and directing traffic with a hand semaphore, are by no means the ultimate.

It is entirely possible to visualize a completely automatic control system efficiently moving traffic in the downtown urban area and on the arterials approaching it. Each individual lane of every street could be controlled by separate signal heads, so that all or any number of lanes could be reversible. Sensing devices would report to a central control station, for each lane in every city block, the numbers and types of passing vehicles, their speeds and headways. A gigantic computer, pre-fed with the solution to every conceivable kind of traffic situation, would anticipate problems and adjust traffic signals accordingly before difficulties could develop.

Message signs might be flashed on, advising drivers to take a nearby parallel street where traffic is lighter; or turn-only signals might be set by the computer to divert a specific portion of the traffic.

Such a system, though vastly complicated, is no more than a direct extension of what we have now. It has two great advantages: First, it could probably be developed and expanded step by step, with no transitional problems; and second, it would require no additional equipment of any kind in the vehicle (except an acquiescent driver). It would require sensing and control devices that have not yet been commercially developed, but which could be without any foreseen difficulties.

### VEHICLE GUIDANCE AND CONTROL

Full vehicle guidance and control in theory involves a computer system, receiving information from sensing devices along the highway and from the driver (who would indicate his destination), and feeding instructions back to the vehicle, in which servo-mechanisms would operate the steering, throttle, and brakes.

Again, the technological problems are not insurmountable, and at least one such system has been experimentally demonstrated.

Tracking and detection equipment for such systems probably would have to be at least in part installed in the vehicle; the servo-mechanisms entirely so.

There are difficult problems to consider in such a system, aside from the technological ones. One of these is cost that would be large for the highway installation alone. In addition, every vehicle using the system would require electronic and mechanical gear. Considering the current costs of car radios and air conditioners, it would not be cheap.

Second, there is the problem of safety, which inevitably would be coupled with responsibility. A vehicle control system obviously should be *fail-safe*. Without saying this is impossible, or implying criticism, the railroads have been working on fail-safe systems for years, yet still there are occasional train wrecks.

If, then, a motorist surrenders control of his vehicle to a state-operated control system, and there is an accident, is the state legally responsible regardless of its precautions? The final answer to that question will come from the courts in some future day.

Third is the problem of transition. I am afraid the popular concept of vehicle guidance and control systems is that some day not too far in the future, suddenly everyone driving from Chicago to Portland (either Maine or Oregon) will be doing it by electronics. But the problems of installation and cost are such that it cannot happen overnight. For a parallel, one has only to remember the long period of transition from the practical development of the turn indicator signal to the time when the device was required by every state, on all new vehicles. There are still probably a fair number of vintage cars on the road without turn indicators.

Even overlooking all of these problems, there remains the final question: on how much mileage, and where, would the vehicle control system be applicable? Certainly not on the hundreds of thousands of miles of country roads that only carry a hand-count of vehicles a day. Even if the 41,000-mile interstate system were taken as the outer limit of practical application, only twenty percent of the total United States travel would benefit.

It is not too great an oversimplification to raise the question: is the control system economically justifiable to the average vehicle owner if he uses it only for one-fifth of his travel? The answer may

possibly be yes, but a good deal of exploration seems called for prior to investment.

What seems to be a more plausible principle than full control of all vehicles on selected highway sections through electronics and servo-mechanisms, are the proposals for a separate, high-speed automatic highway, open—perhaps on a toll basis—to those who choose to use it. The vehicles might run on their own rubber, or be transported on wheeled pallets (like miniature flat-cars); their own engine power might be sufficient, or perhaps auxiliary power might have to be supplied.

Electronic control, of course, would be involved, at least in shunting vehicles onto and off the track. The key feature of this scheme is that vehicles would move safely, bumper-to-bumper, at 150 to 200 miles an hour. For long-distance travel, and especially for extended commuting, the concept offers exciting possibilities. Of course there are many problems to overcome, too, similar to those enumerated above.

## NEEDED RESEARCH

Obviously, no government agency, federal or state, is prepared to build a full-fledged electronic vehicle control system or automatic highway right now. That does not mean, however, that development of the hardware should not proceed, or even that test-sections should not be built. We shall never know whether such dreams are practical and appealing to the public unless they are tried out on some reasonable scale.

We need to do more than the physical research, too. Studies of broad scope and considerable detail need to be made of the economics, potential for service, and the likelihood of public acceptance of any proposed scheme.

## SUMMATION

We need to do much research in the somewhat less glamorous aspects of vehicle or driver guidance and traffic control, also. One important tool in the offing is the driving simulator. When such an apparatus is perfected and available, for the first time we shall be able to study the driver, the vehicle, and the road together and under carefully controlled conditions.

From such studies it is hoped that we can better meet the needs of both the present and the future. Unfortunately, we know not nearly enough of the needs and capabilities of the driver, on which our planning and design of both the vehicle and the road should be based.

I took as my premise for this article that as far ahead as I would care to look, people are still going to want highway transportation of the same basic nature as they now have. The most significant feature of motor-vehicle transportation is that it affords free choice of movement. I can see no reason why the public's enthusiasm for this personal convenience should change; rather, with the likely prospect of higher average income and more leisure time, it should continue to increase.

This factor, coupled with the great diversity of trip purpose that our modern form of living involves, indicates to me that the automobile is here to stay. As the politicians are wont to say of a favorite candidate, it is the people's choice.

# The Future of Toll Roads

SAMUEL P. BROWN

*Mr. Brown has been with Coverdale and Colpitts since 1945. He became a partner in 1952. Educated at the Massachusetts Institute of Technology, he began engineering work in 1936 with Research Corporation, New York City, engaged in design, manufacture and installation of heavy industrial equipment. From 1939 through 1941 he headed a large vocational school in New York and was Engineer in Charge of establishing two small machine shop companies. He served as engineering and procurement officer at Wright Field, Dayton, Ohio, 1941 to 1945, as a Major in the Air Corps. He is a member of the American Society of Mechanical Engineers and American Institute of Consulting Engineers.*

THIS article will consider only briefly the existing toll turnpikes, with comments regarding some of the more interesting developments and problems with respect to particular toll roads. We shall then examine at greater length the much debated question as to whether the federal interstate highway system has or has not caused the end of new toll turnpike projects in the United States.

*Traffic and Earnings of the Turnpikes:* Only two of the existing toll roads have been in grave difficulty from their opening to the present time by reason of traffic and toll revenues woefully below the estimates of traffic engineers. These two projects are, of course, the West Virginia Turnpike and Pennsylvania's Northeast Turnpike to Scranton. (The Calumet Skyway is a major project which is in the same troubled category, but it is primarily a toll bridge rather than a toll road; it is only about eight miles long despite its $100-million outstanding debt.)

The 1952 indenture bonds that financed the Pennsylvania Turnpike's Scranton extension also financed the extension to the Delaware River of the Pennsylvania Turnpike, including Pennsylvania's share of the cost of the bridge to connect with the New Jersey Turnpike. These bonds hold a succeeding lien on the revenues of the principal Pennsylvania Turnpike from the Ohio line to Valley Forge; that is, when the older bonds are paid off in the mid-1960's, the 1952 indenture bonds will have a claim on all of the revenues of the entire Pennsylvania turnpike system.

During the interim until this succeeding lien becomes an active first lien, there will have existed a large surplus of construction funds which will have enabled the continued payment of interest. Accordingly, barring unreasonable delay in paying off the older Pennsylvania Turnpike bonds, the 1952 indenture bonds should be in no difficulty regarding payment of interest and timely repayment of principal.

The West Virginia Turnpike bondholders are in a much less fortunate position. The West Virginia Turnpike defaulted in interest payments a long time ago, and a court decision has required that additional interest be paid on the interest arrearages. The West Virginia Turnpike is, therefore, sinking deeper into debt with each passing year. The inclusion of this turnpike in the interstate system means that it will carry more traffic, some day, from the Pittsburgh-Wheeling-Akron-Cleveland area to South Carolina and points south. Unfortunately, the states of Ohio, Virginia and North Carolina—in addition to West Virginia itself—must build their respective sections of this interstate route, and the latest indications were that at least two of these three states have placed a relatively low priority on this particular interstate construction.

Therefore, there exists not only the question of how much more toll-paying traffic will be brought to the West Virginia Turnpike by these interstate system connections on both ends, but also the probability that the continuous interstate route will not be completed until 1970 or thereafter. Finally, the West Virginia Turnpike Commission has declined to increase toll rates in accordance with recommendations from two different firms of traffic engineers. These recommendations had no official status under the trust agreement, and the commission's consulting engineers have not recommended a toll increase. All in all, the outlook is dim for the next decade, and perhaps brighter but still unclear for the longer-term future.

Through June, 1961, both Richmond-Petersburg Turnpike (Virginia) and Kansas Turnpike have failed to earn their interest requirements. The former adopted a toll rate increase, effective June 1st, which has been highly successful; indications are that net revenues will be increased about $1.0 million a year and that interest will be earned nearly 1.4 times. Kansas Turnpike adopted a

toll rate increase which had not yet become effective when this article went to press, but which is expected to improve revenues materially.

*Existing Turnpikes and Competitive Interstate Routes:* Prospective competiton from Interstate System completions is of almost no concern to the Garden State Parkway, New Jersey Turnpike, New York Thruway, Pennsylvania Turnpike System, Richmond-Petersburg Turnpike, Ohio Turnpike, the original Kentucky Turnpike, Denver-Boulder Toll Road, and the first of Oklahoma's two toll roads. These toll turnpikes are now showing highly satisfactory traffic and revenues, and to this list can be added the Miami-Ft. Pierce "Bobtail" Turnpike in Florida. The latter project, however, does face severe prospective competition between Miami and West Palm Beach from the section of I-95 which will be constructed ultimately in this corridor to the east of the turnpike where it will better serve the string of coastal cities and towns.

Most of the other toll highways not mentioned in the preceding paragraph have shown traffic and earnings performance which has been disappointingly low in comparison with the estimates made prior to financing and construction. The Massachusetts and Maine turnpikes had to increase their toll rates, as did New York Thruway.

In 1961 the Dallas-Ft. Worth and the Kansas turnpikes found it necessary to increase toll rates. The Indiana Toll Road took such action about two years earlier. The latter three toll roads, unfortunately, are among those which face prospective competition from interstate system routes which will seriously reduce the earning capacity of the toll facilities.

In Texas, the highway department and the Federal Bureau of Public Roads thus far have failed to designate the Dallas-Ft. Worth Turnpike as the interstate highway between these two cities. Instead, there remains in prospect a parallel toll-free interstate highway only a short distance to the south of the turnpike. If this toll-free interstate route is approved and built, the adverse effect upon the Dallas-Ft. Worth Turnpike will be serious.

In Kansas the completion of the interstate highway from Ottawa to Emporia will complete an interstate link all the way from Kansas City to Emporia. This is scheduled for construction in the

relatively near future; not only is this toll-free, but also it is shorter than the Kansas Turnpike between Kansas City and Emporia. The completion of this interstate link will remove most of the Kansas Turnpike's traffic which is today traveling the full trip between Kansas City and Emporia, Wichita, or points south and west. Therefore, even though the Kansas Turnpike is itself the interstate route from Emporia to Wichita and to the Oklahoma border, Kansas Turnpike stands to be hurt badly by loss of the Emporia-Kansas City portion of its long-trip traffic, owing to competitive interstate highway construction.

At the west end of the Indiana Toll Road there is also parallel competitive interstate highway construction planned for completion in the relatively near future. The writer is not personally familiar with the current status of this situation, but all indications are that the west end of the Indiana Toll Road will lose considerable traffic. (This traffic loss will hurt Calumet Skyway also.) The big question is whether or not sufficient traffic will be fed to the remainder of the Indiana Toll Road to the east so that the revenue loss may be wholly or partly offset.

Finally, the proposed turnpike extension in Florida can succeed only if I-95 construction is deferred until the end of the interstate program in two vital sections—between Daytona Beach and Ft. Pierce, and between West Palm Beach and Ft. Lauderdale. On the other hand, the proposed Florida turnpike extension from Ft. Pierce to Orlando requires the speedy completion of I-4 from Orlando to Daytona Beach; also, if the turnpike extension is to extend further north, to Wildwood near Leesburg, this requires co-operation in the speedy completion of I-75 from Lake City to Wildwood.

The few examples mentioned above illustrate the need for wise state and federal policy and some deliberate deferrals of parallel competitive Interstate highway construction, if turnpike investments—in toll roads having ample capacity to serve the traffic—are not to be jeopardized.

## FUTURE OUTLOOK FOR NEW TOLL ROADS

In mid-1956 the Congress of the United States passed the legislation authorizing the 41,000-mile interstate highway network, and launching the program to build this interstate system with ninety

percent of the construction costs paid by the federal government. At that time the various toll turnpike projects then pending were shelved and widespread opinion was that no more toll roads would be built in this country. The writer did not agree with this opinion, particularly not for the long-term future.

In December of 1957, when the interstate program was some eighteen months old and the various states were beginning to understand the magnitude of their own construction programs to build their respective shares of the interstate system, the writer spoke to The Municipal Forum of New York, an organization of the tax-exempt bond experts from the investment banking community, and stated that:

—quite probably there would be no new toll road projects financed for a period of two or three years;

—probably no toll *highway* projects (as distinct from bridges or tunnels) would even be studied during 1958 and 1959;

—as the citizens in certain states learned (a) that the interstate system does not include all necessary arterial highways within a state, and (b) that in every state some interstate highway projects must be deferred until the last years of the program in the 1970's, a resurgence of engineering studies of toll roads might be expected in 1960 and 1961, with the financing of some of these projects upon a toll basis to follow thereafter.

Sometimes engineers must look back upon their estimates and predictions and seek explanations as to why actual developments have proved to be different from the most carefully calculated prognostications. The above-summarized opinion and prediction of December 1957, however, has proved remarkably close to the mark.

*Three Illustrative Projects:* In August of 1959 the firm of Coverdale & Colpitts was engaged to make traffic studies and revenue estimates for a proposed Atlantic City-Philadelphia superhighway on a toll road basis, and to make related traffic estimates upon the assumption that this project would be built as a free highway. The firm of Parsons, Brinckerhoff, Quade and Douglas was engaged about the same time to make civil engineering studies and construction cost estimates for this highway. The route across southern New Jersey is presently served by two obsolete state highways and this

particular traffic corridor is one of many which is not included in the interstate system.

The studies for the Atlantic City-Philadelphia toll road were delayed, for a variety of reasons not within the control of the engineers, but were finally proceding to completion as this article was written. Whether or not this project proves to be financially feasible for financing solely upon the basis of its prospective toll revenues, our point here is that in 1959—only three years after the interstate program was born—New Jersey launched this study of a proposed toll road project. It appeared reasonably certain that the State of New Jersey could not build as a free road this desirable new superhighway.

A second and more widely publicized toll road project is the proposed northern extension of the Sunshine State Parkway in Florida. Early in 1960 the Florida State Turnpike Authority commenced to make formal studies of a proposed extension of the Florida Turnpike from Ft. Pierce to the vicinity of Orlando, Florida. This project could have been brought to the point of financing prior to December 1960, but only by refunding of the bond issue which financed the original Miami-Ft. Pierce Turnpike in Florida. Inasmuch as these 1955 bonds have a 3.25 percent coupon, it was understandable that considerable controversy arose as to whether or not it would be worthwhile to refund them when the new bonds would have required an interest rate of 4.50 percent or higher. Upon this financing question and public policy debate the Florida Turnpike extension project foundered in 1960, which was the sixth and final year of a gubernatorial administration.

In 1961, however, the new administration in Florida obtained sufficient public support to make the determination to build a turnpike extension to Orlando, or even further north, upon the basis of refunding the 1955 bond issue. At this writing (early July) the engineering, financial and legal studies are nearing completion. Barring unforeseen delays, it is a reasonable expectancy that this toll road project in Florida—a turnpike extension from 100 to 150 miles long—will be financed in the fall of this year.

A third example is found in Massachusetts. In April and again in June of this year the Massachusetts Turnpike Authority endeavored to finance the short extension into downtown Boston of the

Massachusetts Turnpike. For a variety of reasons neither of these efforts succeeded. Certainly one reason was the existence of strong controversy in eastern Massachusetts as to whether this project should be built promptly as a toll road, or should be built some years later as a unit of the interstate highway system. The opponents of the toll road project, in advocating the toll-free interstate alternative, avowed that the project could be completed "almost as soon" upon a toll-free basis. An equally impressive body of opinion in Massachusetts believes that construction of this particular project (or one of various proposed alternative routes) could not be completed as a toll-free highway until 1970 or later.

It is entirely possible that, as the Massachusetts highway construction program and highway budget for the early 1960's becomes more clear during the next year or so, it may be found that the toll-free highway construction would be impossible until so late a time that the delay would not be tolerated by public opinion.

The three projects discussed above serve to illustrate three conditions which have caused state governments and the informed motoring public to turn again toward revenue bond financing of toll highways in order to accomplish timely construction of desirable new highway projects. The Atlantic City-Philadelphia proposal illustrates a road through primarily rural country, where there is no possibility of having the route included in the federal interstate system. The proposed northern extension of the Florida Turnpike illustrates a similar situation, complicated by the fact that the interstate system in Florida does include I-95 along the east coast, from Miami to Jacksonville and to the Florida-Georgia state line.

Despite the fact that this interstate highway along the east coast will exist some day—but, between Daytona and Ft. Pierce, probably not to be built until the last year or two of the interstate program—Florida has decided, in effect, that it needs the toll turnpike up into the center of the state and needs it badly enough to perpetuate tolls for the indefinite future on the existing Florida Turnpike. The importance of this decision is understood only upon realizing that the existing Florida Turnpike probably could pay off its outstanding bonds and could become toll-free by the early 1970's, if its earning capacity were not used to help finance additional turnpike mileage to the north.

The third example, that of the Boston extension of the Massachusetts Turnpike, illustrates a short urban section of highway, part of which is included in the interstate system. Here the choice of a course of action becomes the dilemma between getting the toll-free highway in service eight or ten or twelve years from now versus the possibility of building a toll road which could be open to traffic within three years.

*Nationwide Prospects—Next Decade:* Turning to other parts of the United States and considering the prospective place of toll roads during the next ten years, we can eliminate large areas of the country with respect to long-mileage toll roads traversing rural areas between cities.

*West of the Mississippi:* For example, on the West Coast, California has an established policy against toll highways, although the state has shown no reluctance to use the toll revenue principle for the financing of necessary bridges. California is fortunate in having had the courage to increase gasoline taxes nearly fifteen years ago and to launch an enlightened highway construction program, both in terms of urban expressways and with respect to its more heavily traveled sections of inter urban highways through rural country. California is fortunate in a second respect, inasmuch as its major trunk highways are included in the federal interstate system and California was ready with a well-planned program and with plenty of money to provide the state's ten percent toward the cost of interstate system projects.

To the north on the coast, Oregon never seriously studied any toll highway projects and the State of Washington gave serious study to only one project. The latter was a proposed toll road from Tacoma northward, slicing through the heart of Seattle as an urban expressway, and continuing north to Everett. This project has been definitely dropped as a toll road; it is included in the interstate system; and it has been given high priority for construction on a reasonably prompt time schedule.

Considering the Rocky Mountain states, construction costs per mile are relatively high; traffic densities are relatively light; no real toll highway projects have been considered in these states; and it is the writer's opinion that no toll road projects will warrant study in this area during the next decade. While this conclusion is unqualified with regard to toll highways, it remains entirely possible

that there will be a few bridges, and perhaps one or two tunnels, with relatively short express highway approaches, financed wholly or partially upon a basis of toll revenues.

Considering the tier of states between the Rocky Mountains and the Mississippi River, there is the thirty-two-mile Dallas-Ft. Worth Turnpike in Texas, the two turnpike projects (joined by a short toll-free express highway link) in Oklahoma; there is the Kansas Turnpike plus its short urban extension into Kansas City; and there is the short Denver-Boulder Turnpike in Colorado.

Other turnpike projects have been studied in Texas, Oklahoma, Kansas, Iowa, Nebraska and Wisconsin—all of these were found financially not feasible, except with subsidies from the state general fund or the highway fund so high as to be unacceptable. Again in these states, it is the writer's opinion that vehicular toll facilities will be limited to water crossings with relatively short express highway connections and that rural toll roads of any substantial mileage will not be built during the next decade.

*Central States:* Turning east of the Mississippi River, a north-south toll road was studied in Michigan, from the state line near Toledo through the western suburbs of Detroit and northward to serve Pontiac, Flint, and perhaps points north. This toll highway project was found not financially feasible back in 1955 and with the advent of the interstate system it is being built as a toll-free interstate highway. The Detroit-Chicago toll turnpike, which received preliminary study prior to 1956, is in the same situation.

Although both Indiana and Ohio studied other toll road projects beyond their existing toll turnpikes, it now appears that neither state has a traffic corridor with both the traffic density to warrant a toll road, and the absence of timely interstate system sections to serve the need. The same may be said of Illinois, where the Chicago-St. Louis toll road was once a project under study.

*South and Southeast:* To the south, the states of Tennessee, Louisiana, Mississippi, Alabama, Georgia and the Carolinas will doubtless find their trunk highway needs served sufficiently well and sufficiently soon by the evolving interstate system routes within their borders, provided a sensible job of scheduling and priorities is followed. Florida was mentioned previously. Virginia has its Richmond-Petersburg Turnpike, part of Interstate Route I-95, and

the West Virginia Turnpike is included in the interstate system. Neither Virginia nor West Virginia has prospects of another toll turnpike.

*Mid-Atlantic States:* Since early 1960 the states of Maryland and Delaware have recognized and shared a common problem. The interstate system includes a very important route extending some thirteen miles across Delaware from the Delaware Memorial Bridge over the Delaware River, then continuing across Maryland to Baltimore and a direct connection with the Baltimore Harbor Tunnel. Both of these states have concluded that this important interstate route, paralleling Route US 40, cannot be completed as a toll-free interstate facility until perhaps 1970 or even later. Accordingly, the two states launched parallel and co-operative studies of the project as a toll facility.

The fundamental economic feasibility as a toll project has been demonstrated; the practical financial feasibility depends upon many factors, including the status of the bond market and a number of legal and administrative questions. A major problem is the fact that the two separate projects in the adjoining states should be financed simultaneously, with assurance that they will be completed and open to traffic on the same date. Their toll schedules must be co-ordinated to avoid driving away toll traffic in both states by an ill-advised toll rate structure in one state.

Subject to the satisfactory resolving of the problems indicated above, it is the writer's opinion that there is better than a 50–50 chance that the Delaware Toll Road and the Maryland Northeastern Toll Expressway will be financed in 1962, as two separate but closely co-ordinated toll road projects, with or without some possible subsidy by one or both states.

The proposed Atlantic City Toll Road in New Jersey has already been discussed. There is also presently under study the possible extension of the New Jersey Turnpike to connect with a New York Thruway spur at the state line, a short distance south of Nyack, New York. Beyond this it is doubtful that any further toll highway projects will be studied in New Jersey (or in Pennsylvania) during the next decade.

New York State has, in its New York Thruway, the most costly single toll highway project in the country. Much of this mileage,

including the New England Thruway across Westchester to connect with the Connecticut Turnpike, has already been incorporated into the interstate system. Accordingly, while additional toll crossings and specialized short urban toll expressways may be studied and possibly built in New York State, it is the writer's opinion that no additional major toll roads will merit study in New York.

*New England:* The relatively small state of Connecticut already has its Connecticut Turnpike, of which the coastal portion from the New York state line to the vicinity of Flanders Village is already designated I-95. With this most costly portion of its interstate system already completed—and the structures alone in the 50 miles between New Haven and Greenwich cost approximately $100,000,000—Connecticut appears to have its interstate system well in hand and no further toll highway prospects exist. In Vermont and Rhode Island some toll turnpike possibilities were under consideration in 1956, but apparently both of these states are now capable of completing their Interstate mileage sufficiently rapidly so that consideration of toll roads has been dropped.

Massachusetts already has the Massachusetts Turnpike extending from the New York Thruway connection to Route 128 on the fringe of the Boston-Cambridge metropolitan area. The possible Boston extension of the Massachusetts Turnpike has already been discussed as a special project.

The other two New England states, Maine and New Hampshire, were among the pioneers in building toll turnpikes. Maine was the first with its turnpike from the New Hampshire state line to a terminus just south of Portland. Subsequently, this initial Maine turnpike project was refinanced and an extension was built to Lewiston and Augusta. It appears certain that there are no further toll turnpike prospects in Maine.

New Hampshire presents an interesting and exceptional situation. The three toll turnpikes in that state were studied carefully as to economic feasibility, whereupon the state gave a guarantee of full state faith and credit to the bonds to finance these projects. The first project was, in effect, an extension or connection from the initial Maine Turnpike across New Hampshire to Massachusetts.

New Hampshire obtained remarkably low interest rates on its turnpike bonds by virtue of the state guarantee. Here again, similar

to the situations in Connecticut, New York, Pennsylvania and other states which financed toll turnpikes prior to 1956, it appears clear that New Hampshire will be able to complete the rest of its interstate highway program without considering additional toll turnpike projects.

*The Kentucky Situation:* With respect to toll turnpikes, the State of Kentucky presents an unusual and exceptional situation. In financing its original Kentucky Turnpike, from Louisville to a point just south of Elizabethtown, Kentucky was an early and successful pioneer. It was authorized by its legislature to make the Kentucky Turnpike bonds essentially *gross* revenue bonds, inasmuch as the state agreed to pay all maintenance costs and operating expenses on the Kentucky Turnpike.

This project has now been open for five years and, while its revenues have been consistently below estimates, its gross revenues now more than cover total debt service and it has been incorporated into the interstate system as a part of I-65. Effective September 1, 1961 the Kentucky Turnpike increased its toll charge for a full-length passenger car trip from 60 cents to 70 cents with proportionate small increases for trucks. The long-range financial success of the Kentucky Turnpike appears very well assured.

This much represents simply a fairly routine experience for a state which was one of the pioneers in building a toll turnpike. The unusual and exceptional situation in Kentucky stems from the two other turnpikes now under construction in Kentucky.

In 1961, Kentucky has financed two toll turnpikes under The Turnpike Authority of Kentucky, which is a *non-operating* agency. The 43.5-mile Eastern Kentucky Turnpike, 127 miles long, required a bond issue of $39,000,000. The Western Kentucky Turnpike, 127 miles long, required a bond issue of $118,000,000. These two toll turnpikes are not expected to come close to being self-sufficient for a great many years, insofar as earning from their net revenues the debt service on these two bond issues.

For example, during its first five years the estimated toll revenues on the Eastern Kentucky Turnpike will average only about $675,000 a year, while maintenance costs and operating expenses will run about $300,000 per year. The indicated average net revenue over this initial five-year period is estimated at only about

$375,000 per year, which is less than one percent of the $39,000,000 bond issue or about one-fifth of the $1,827,000 interest expense.

The financing of the Western Kentucky Turnpike, similarly, was not based upon its prospective toll earning capacity. Its estimated net earnings (toll revenue less maintenance and operation expenses) for its first five years average only about $1,800,000. This is less than one-third of the $5,653,000 annual interest on the $118,000,000 debt.

Both of these toll roads in Kentucky call for annual rental payments by the highway department to the turnpike authority, the annual rentals being $2,500,000 and $7,225,000, respectively, on the eastern and western projects. Under the leases, the highway department will also pay all current expenses and will retain the toll revenues.

The financing of the eastern and western turnpikes in Kentucky caused much discussion in financial circles. The highway department lacked the legal authorization to make a single long-term lease, and can only make a binding rental commitment two years at a time. It is possible that a future legislature in Kentucky might make it impossible for the highway department to enter into renewals of these two leases, in which event the estimated project revenues would not be sufficient, on either the eastern or the western turnpikes, to cover principal and interest requirements.

The purchasers of the bonds were asked, in effect, to gamble that such a possible lapse in the contemplated highway department rental agreement would not last longer than two or three years, for which period the funded reserve account would be sufficient to permit the turnpike authority to continue principal and interest payments.

Because of this unusual situation, the eastern and western toll roads in Kentucky, financed in February and in June of 1961, respectively, involved net interest costs in the range of 4.8 to 4.9 percent. There was a large segment of opinion in financial circles that Kentucky could have obtained much lower interest rates on both of these bond issues if the state had been willing and able to make a simple and clear pledge of sufficient gasoline tax revenues to cover the debt service for the life of the bond issues.

Indeed, if such a pledge had been made in a manner to include

payment of interest during construction, the Western Kentucky toll road could have been financed with a bond issue of $95,000,000 or less instead of $118,000,000; similarly, the Eastern Kentucky Turnpike could have been financed by a bond issue of about $33,000,000 instead of $39,000,000. Moreover, over life of the two bond issues, savings of many millions of dollars of interest expense would have been possible. The foregoing comments, which were widely prevalent in the financial community in New York and Chicago and among institutional investors, are not a criticism of Kentucky for financing its eastern and western toll roads in the manner actually utilized.

Instead, it is a criticism of restrictive constitutional and statutory provisions which did not permit the state administration to utilize the much less expensive means of financing by an outright pledge of gasoline tax revenues. The fact that the projects were financed in the more costly manner is an indication of the urgency of the need for these two new highways, as determined by Kentucky in studying its over-all highway needs. In other words, here is an outstanding example of major superhighways needed in the state but not included in the interstate system, which could be built promptly only by borrowing the money required to build them.

## SUMMARY

Many of the toll highways showed in their early years traffic and revenues considerably below estimates. Traffic grew rapidly on most projects, and toll rate increases were made at various times through mid-1961 on a half dozen of the toll turnpikes. At present and for the near-term future, only West Virginia Turnpike appears to remain in serious financial difficulty from the viewpoint of its bondholders. For the longer-term future, however, several of the toll turnpikes (such as Indiana, Kansas and Dallas-Ft. Worth) do face the prospect of serious competition from parallel toll-free interstate highway projects.

The initial guesses in 1956 that the 41,000-mile interstate system meant the end of toll roads in the United States now stand—only five years later—proven to be not correct. In 1961, we find toll road projects actually financed, probably to be financed, or under

study in half a dozen states, to the extent of more than half a billion dollars. In other special situations, where interstate system construction cannot proceed sufficiently rapidly to meet the needs or where a route is not included on the interstate system, we may expect to see other toll road projects proposed and studied.

With or without some sort of capital grant or annual subsidy toward debt service, some of these toll turnpike projects will be financed and built as toll highways. Finally, we may expect that some crossings of rivers and harbors surely will continue to be built as toll projects as they have been for the past 35 years since the Holland Tunnel and the Philadelphia-Camden Bridge pioneered the era of such toll crossings.

# Land Use at Freeway Interchanges

WILLIAM C. PENDLETON

*Mr. Pendleton is an Agricultural Economist, in the Land and Water Economics Branch, Farm Economics Division, U. S. Department of Agriculture. His current assignment is the inventory and analysis of the major uses of land in the United States. From 1957 to 1959 he was in charge of a research project conducted in co-operation with the Bureau of Public Roads, dealing with the impacts of highway improvements in rural areas. He holds a Master's degree in Economics from the University of Chicago and is writing his Ph.D. dissertation on the relation of residential land values to highway benefits. Mr. Pendleton is a member of the Highway Research Board Sub-committee on the Indirect Effects of Highway Improvements. He has published three reports to the Bureau of Public Roads covering research results from co-operative projects; and "The Economic Effects of Highway Improvement on Land Resources," Chapter 12,* Modern Land Policy, *University of Illinois Press, 1960.*

MAJOR transportation improvements are powerful determinants of the nature and intensity of land use. In the last century, the building of the railroads played a dominant role in locating towns and cities and in developing the country's agricultural and industrial resource base.

Later, the structure of our major cities was shaped in important respects by the subway, the commuter train, and the electric railway. The last several decades have seen the highway replace these forms of mass transportation in transforming old land-use patterns and in shaping new ones.

## THE PROBLEM

Much attention is currently given to the impacts on land use of building the national system of interstate and defense highways. While the ultimate effects can scarcely be foreseen, even in broad outlines, the focal points for much of the change induced by the new highways will probably be the interchanges that provide means for entering and leaving the freeways.

AUTHOR'S NOTE: This article is drawn in large part from a research report prepared for the Bureau of Public Roads by the Farm Economics Division, U. S. Department of Agriculture.

Effective controls over access will prevent the ribbon pattern of commercial development that has taken place along so many uncontrolled facilities and will tend to concentrate commercial activities in interchange areas. Residential and industrial users of land will favor locations near interchanges in order to take full advantage of the improved access provided by the Interstate highways. Additional demands for frontage on crossroads in the immediate vicinity of interchanges will stem from the legislative prohibition of service facilities on interstate system rights-of-way. Therefore, the prospect is that interchanges will tend to concentrate around themselves much of the land development associated with the new highways.

Recognition of the critical importance of interchanges has led to concern over the adequacy and appropriateness of the controls that local and state governments will exercise over changes in land use.[1] Many interstate system interchanges will be located in rural areas where most of the land is currently in low-intensity uses. This fact, coupled with the inexperience of many county and municipal governments in controlling the use of land, has led to the expectation that development will be rapid and, in most areas, inadequately controlled.

Apprehension about the land-use patterns that may develop takes two forms. The first is the traditional concern of the city planner with the compatibility of particular uses and with the aesthetics and efficiency of the pattern of development. This view holds that developments detracting from the value of land in neighboring alternative uses need to be discouraged and the growth of undesirable patterns of commercial and industrial use prevented. Some form of zoning is generally looked to as the means of avoiding these uncontrolled changes.

Perhaps embraced in the urban planner's viewpoint but with a more limited and specific focus is the second approach to land-use change—that of the highway engineer. He has responsibility for designing, locating, and constructing new highway facilities that will

1. Controls over changes in land use are conceived broadly to include zoning, setback regulations, subdivision controls, official mapping, and other exercises of the police power. Discussions of the legal and administrative problems involved can be found in: William H. Stanhagen, "Highway Interchanges and Land Use Controls," Highway Research Board Annual Meeting, January 1961, and a forthcoming Marquette Law Review article by Frank M. Covey, Jr.

be in service decades after they are built. In addition, present highways constitute a tremendous capital investment whose present and future usefulness is a primary concern of the highway engineer. For both new and old facilities, efficiency requires that the kind and volume of traffic be in balance with the capacity of the facility.

The highway planner in particular is faced with the problem of forecasting volumes of traffic ten, twenty, even more, years in the future, so that the highway he designs can handle the demands that will develop in later years. Crowded, congested highways in every state testify to the imbalance that develops when future traffic volumes are underestimated in the planning process.

A major determinant of the kind and volume of traffic is the use of the land served by the highway. While much is still to be learned about the traffic-generating characteristics of various land uses, it is clear that different uses are associated with different patterns of traffic. Any attempt, therefore, to forecast traffic must either explicitly or implicitly take into account expected land-use patterns. The use of land is particularly critical in predicting generated traffic—additional traffic induced by the construction of the improvement.

This traffic-generating aspect of land-use change is of particular concern to the highway engineer. Highways already in existence can be rendered obsolete long before the end of their physical lives by traffic developing from new land uses. In planning new highways, an accurate picture of future uses of land is essential if realized future traffic is to correspond with the predictions on which design characteristics are based. Thus the highway engineer's interest in land-use change is derived directly from his responsibility for balancing highway capacity with future volumes of traffic.

For interchanges on the interstate system, highway planners at appropriate levels of government need to concern themselves with the future adequacy of at least three facilities: the interstate highway at the interchange, the intersecting highway for a considerable distance on each side of the interchange, and the interchange ramps and such related structures as acceleration and deceleration lanes. The amount, kind, and time-distribution of traffic using these three facilities are related to the kinds of land use that develop in the area around the interchange itself.

Particularly critical is the pattern of development along the

intersecting highway—the crossroad. Access controls on the interstate highway and on interchange structures go far toward preserving the usefulness of these facilities, but such protection does not necessarily exist for the crossroad.

Not only may it suffer from an excessive number of vehicles moving along it, but uncontrolled access to service stations, restaurants, motels, shopping centers, and other traffic-generating developments may quickly create the kind of congestion often encountered in the commercial strips on many highways today. As this commercial-industrial development slows traffic along the crossroad and interferes with the movement of vehicles to or from the interstate highway, congestion on the crossroad is transferred to the through-facility.

If the traffic volume should require a traffic signal on the crossroad, traffic may back up on the interchange ramps and possibly on the interstate highway itself. The prospect of premature obsolescence of any of the facilities involved calls for a thorough investigation of the interrelations among land use, traffic, and the design of highway improvements.

In planning for an acceptable combination of traffic and facility capacity, three variables are under the control of the highway planner in varying degree. The first is the design of the interstate highway, of the structures that comprise the interchange, and, to a considerably lesser degree, of the crossroad on either side of the interchange.

The number and width of lanes on the main facility, together with the capacity and other design features of interchange ramps, can be varied within wide limits in the planning stage. The crossroad, however, is already built—its capacity was decided years ago—and it may be bordered by commercial, industrial, or residental structures that would make widening prohibitively expensive. Thus while the planner has considerable flexibility in designing the new facilities, his control over the critical design features of the crossroad may be severely limited.

Related to design characteristics but deserving separate mention is the second variable—access characteristics. With access points on interstate highways confined to interchanges, the discretion of the highway planner extends to the spacing and frequency of interchanges and to controls over access to the crossroad. The

location and frequency of interchanges will influence directly the pattern of land development that takes place and will thereby help to determine the composition and rate of movement of traffic on the highway.

Volume and flow of traffic on the crossroad also will be influenced by the characteristics of access between it and adjacent land. To the degree that it is feasible to limit the number of access points or to control the type of access, the threat to the traffic-carrying capacity of the road will be lessened. As with design considerations, the highway planner generally will be able to control access much more completely on the new facility than on the crossroad. The presence of vested and valuable access rights will probably limit severely the feasibility of changing the pattern of access existing on the crossroad.

The third variable relevant to balancing traffic and highway capacity is the pattern of land-use that will develop in the area served by the improvement. Changes in land-use and in associated traffic are less well understood and less amenable to control than design and access features. Highway planners have found it impossible to take future land-uses into account in a thorough and systematic way when they estimate future traffic volumes.

Not only is the relation between specific uses and generated traffic imperfectly understood but even less is known about the determinants of land-use change. Models of land development have not been refined to the point at which the traffic engineer can use them with confidence in predicting future traffic patterns. The highway planner is also handicapped by having little if any control over the changes in the use of land after the facility is constructed.

Direct public control over land-use change lies primarily with agencies other than highway departments. While indirect controls are exercised through decisions as to design and access control, the regulation of land use is almost exclusively a function of county and municipal governments. As a consequence, co-ordination of highway planning with land-use planning has been inadequate; increasing interest is shown both in promoting closer co-operation between highway and land-planning agencies and in transferring to highway departments limited controls over land-use change in the immediate vicinity of highway improvements.

The desirability of co-ordinating these three variables—highway

design, access characteristics, and changes in the use of land—should be obvious. Only if decisions in these areas are consistent will traffic be efficiently balanced with highway capacity. At the same time, it is clear that there are formidable obstacles to achieving the desired co-ordination and consequent balance. Chief among these are the shortcomings in our techniques for prediction and the relative independence of state highway departments and county or municipal land-use planning agencies.

Another obstacle to effective co-ordination is the absence of generally accepted criteria to govern the relations among design, access features, and land-use controls. In planning of new facilities, highways adequate for future traffic can be assured either by developing techniques for predicting traffic and designing facilities that will accommodate it, or by designing highways for given traffic volumes and then controlling traffic so that the facility is not overloaded.

The first of these procedures is to adjust the highway to the traffic; the second is to adjust the traffic to the highway. Clearly, no highway planning agency follows one of these courses exclusively. Expected traffic will always enter into design decisions, and as noted earlier, the *existence* of access-controls tends to regulate the amount and pattern of traffic.

### THE TWO APPROACHES

Recognition of the two approaches is useful, however, because they have different implications for highway design, access controls, and land-use controls. To the degree to which primary reliance is on design for future traffic, the responsibility of the traffic engineer for making traffic projections in which confidence can be placed is obvious. Such estimates require projections of future land uses and of the corresponding volumes and patterns of traffic.

The philosophy behind this approach is that land-uses and the traffic associated with them will be permitted to develop in response to market forces, land-use capabilities, and whatever zoning regulations may be imposed. The job of the highway planner then becomes one of projecting land uses and traffic within the framework of the most likely combination of these factors and designing the highway accordingly.

Adoption of the second approach—controlling traffic to protect the highway facility—could involve a variety of measures related either to access features or to changes in the use of land. Access controls, while designed primarily to limit the number and location of points of access to the highway, also include measures to regulate the kind of traffic *gaining* access or the maneuvering of vehicles at access points.

Controls over the use of land are suggested primarily as a means of regulating the volume and time pattern of traffic. For interchange areas, the suggestion has been made that zoning controls be imposed that will prevent the development of certain kinds or excessive amounts of traffic. "Large lot" requirements for subdividers would be one technique for limiting traffic originating at residential sites. Similar regulations could be imposed on industrial and commercial development, again with a view to adjusting traffic demands to the capacity of the highway or interchange.

Devising techniques for protecting the crossroad appears to be both more urgent and more difficult. The flexibility that highway planners have in designing and controlling access on new facilities offsets in large part their lack of control over land-use changes. This is not the case with the crossroad. Highway planners are not only faced with design and access-control decisions made years ago; they also have little if any control over future developments.

As a minimum, new land uses along the crossroad should be required to observe reasonable setback distances and to provide adequate parking for the vehicles attracted to them. The development of additional techniques for assuring an acceptable combination of traffic and capacity on the crossroad presents a challenge to the traffic engineer, the economist, and the student of law.

## A PROGRAM OF RESEARCH

It will be useful to consider separately six phases of research on the implications of changes in land use in interchange areas. The interrelations among these six phases will be obvious; they should be worked on simultaneously.

1. *Definition of the problem:* The precise nature of the threat to interchanges from changes in land use deserves attention. In what ways and to what degree are the various facilities vulnerable to

generated traffic? Is the problem one of protecting the freeway and the interchange structure, or is it confined to the crossroad? A careful statement of the conditions under which one or more of these facilities might be rendered prematurely obsolete is needed.

Consideration should be given to the implications of particular patterns of traffic generation, distinguishing among the problems raised by the volume and time distribution of traffic as opposed to the congestion caused by the parking, loading and unloading, or maneuvering of vehicles. Problems will differ at the different interchanges, but typical patterns of traffic generation can be delineated. The problem as thus defined will determine the appropriate approaches to research on both land-use change and public measures to control it.

2. *Development of predictive models for land-use change:* Decisions on design of new facilities, control of access, and regulation of changes in land use must be based on assumptions regarding the kinds and amounts of development to be expected in the interchange areas. Much needs to be done in the direction of isolating the determinants of land-use change, of determining the mathematical relationship between these factors and changes in use, and of developing useful measures or estimates of the determinants.

The resulting predictive technique should be geared to forecasting the amount, kind, and general location of future changes in the use of land. Because the analytical tools available for this task are still crude, *precision* in the forecasts of changes in use cannot be expected. Something meaningful can be pointed out, however, about the general magnitudes of development of different kinds that the interstate system will bring.

One approach would be to estimate for a segment of highway or perhaps for an urban area the amounts of development of different kinds that can be expected during the study period. Broad classes of land development such as light and heavy industry, single- and multiple-unit residences, services to highway users, and other commercial uses would be more manageable than the finer classifications developed for other purposes. As the study area would probably embrace several interchanges, it would then be necessary to allocate expected changes to specific interchange areas.

In this allocation such factors as present development, location with respect to urban centers, expected traffic on both the crossroad and the freeway, and the physical characteristics of land should be considered. A refinement that might prove fruitful would be to introduce into the model available information about locational linkages among specific uses of land.

Such linkages would be a further determinant of where changes in use will take place. The more specific question of where *within* an interchange area particular uses will be located probably cannot be answered until more is known about the broader regional determinants of land development.

In contrast with many studies dealing with the effects of highway improvement, the purpose of the model under discussion is *not* to isolate the role of the interchange or the highway in inducing shifts in the use of land. It is rather to predict the joint effect of all relevant determinants. The generative effects of the highway must be combined with the influence of population growth, increases in income, technological change, topography, and public policies. These and perhaps additional forces contribute to the rate and pattern of land development, and all may need to be considered in developing a useful predictive model.

3. *Determining traffic-generating characteristics:* This is a task for the traffic engineer, and it is one on which much good work has already been done. It is clear that forecasts of changes in the use of land will have little utility to the highway planner unless definite kinds, volumes, and patterns of traffic can be associated with them.

4. *Classification and collection of data on land-use changes:* Basic to prediction of future land uses is knowledge of current patterns of use and knowledge of the time sequence and spatial arrangement of changes in use. For maximum usefulness, this information must be classified into categories that will be meaningful to those who use the data. In deciding upon appropriate classifications, two restraints should be kept in mind.

The first is that the classification scheme should be meaningful in terms of traffic generation; that is, land use should be classified so the traffic engineer can tie *traffic* predictions to the *land-use* predictions. The second restraint is that the classification must also be designed to fit the predictive models they will be used to verify.

Classes of land use should be so set up that they can be related to the causal factors producing change.

5. *Legal analysis of access and land-use controls:* Much work remains to be done in studying the legal and administrative aspects of the relation of access and land-use controls to traffic problems. Growing concern over congestion has led to increased awareness of this relationship and to serious consideration of gearing land-use measures directly to the protection of highway investments. Study is needed as to what measures currently used by states, counties, and local governments might be appropriate to this problem. In addition, exploration of the feasibility and legality of new and untried techniques should be carried forward by legal scholars.

6. *Economic analysis of access and land-use controls:* Achieving the appropriate combination of design, access controls, and land-use controls may be viewed as a problem in economic efficiency. Different combinations of these three factors are associated with different costs and benefits, and consequently, with different amounts of net social gain. Maximizing the gain is the basic problem from the economic viewpoint. Unfortunately, little has been accomplished in the direction of identifying and measuring some of the most relevant costs and benefits, and the evaluation problem is further complicated by the close interdependence of the economic effects of each of the factors.

Among the costs and benefits involved, good estimates are available only on the costs of alternate design characteristics. The benefits from higher design standards and more rigid controls over access have been studied from the viewpoint of savings in time, accidents, and vehicle operating costs, but satisfactory economic measures of many of these effects are not available. Particularly needed is further economic research on the effects of land-use controls. While much attention has been given to legal analysis, practically nothing has been done on the benefits and costs of alternative control techniques.

Controls over the use of land that cause the pattern of use to be different from what it would otherwise have been result in gains and losses that should be taken into account. Frequently, these economic consequences are ignored because they do not require direct expenditure of public or private money or because they are

not clearly evaluated in a market. Neither consideration should preclude an attempt to identify and estimate the relevant consequences.

Protecting the traffic-carrying capacity of the crossroad may involve either converting the road to the controlled-access type or forbidding commercial and other types of development along it. Both alternatives entail costs, although the costs involved in forbidding land development are difficult to recognize and to measure. They consist primarily of the extra time and other transportation costs that potential users of adjacent land would incur.

To the degree that motels, gas stations, warehouses, and factories are diverted from locations along the crossroad, they will be on inferior sites, and the social loss involved is a cost of the regulatory measure. Density controls on residential development also result in costs that may not be immediately apparent. Providing public services to low-density housing costs more per capita than providing them to more densely settled areas, and the aggregate costs of travel to a population center will vary directly with residential dispersion. These and similar examples warn that regulation of land uses along crossroads may not be as costless as it appears to be.

This is not to argue that beneficial effects of access-controls and land-use regulation may not outweigh the adverse effects. In many instances, community or broader social interests diverge from the interests of private landowners, and public interference to harmonize these divergences is justified. The use of land in interchange areas may well fall into this category; public regulation may be necessary if an efficient land-use pattern is to be achieved. To the degree that standards of economic efficiency govern, the gains need to be compared with the costs, and both gains and costs should be sufficiently broadly conceived to encompass all relevant economic effects.

Benefits from land-use controls in interchange areas are mainly savings in time and other vehicle operating costs arising from the protection afforded the highway facilities involved. The costs are of the kind just discussed. Comparison of the benefits and costs is one step in the evaluation problem. A second step is comparison of benefits and costs from alternative means of achieving a balance

between facility and traffic. Purchase of access rights on the crossroad is one possibility; another is increasing the traffic capacity of the crossroad through widening or imposing traffic controls. All of these possibilities are subject to economic calculation, and efficiency requires that their net value be estimated.

## CONCLUSION

Land development in interchange areas is one of the most difficult problems currently faced by land-use planners and highway planners. Some of the alternative solutions have been sketched in the foregoing paragraphs and a summary of the most promising lines for research has been presented. Highway officials have the major responsibility for recognizing the problem, publicizing it, promoting research to provide data and analysis that will be useful in guiding policy, and bringing to these questions the originality and inventiveness they demand.

# Effective Traffic Court Penalties

JAMES P. ECONOMOS

*Mr. Economos has served as Director of the Traffic Court Program of the American Bar Association since 1943. He is a member of the National Committee on Uniform Traffic Laws and Ordinances, National Committee for Traffic Safety, is Chairman of the Committee on Alcohol and Drugs of the National Safety Council, and is Secretary of the Committee on Enforcement-Courts of the President's Committee For Traffic Safety. He is a member of the American Bar Association (National Chairman of the Junior Bar Conference—1943–44), (Secretary of Special Committee to Improve Administration of Justice—1943–46), (Assistant Secretary—1948–51); Illinois State Bar and Chicago Bar Associations. He has directed traffic court conferences at leading law schools throughout the country since 1947. He has directed surveys of traffic courts of eight states and many cities. In 1959–60, he assisted the government of Metropolitan Dade County, Florida to establish a Metropolitan Court, superseding twenty-six municipal courts for hearing traffic charges. He has contributed articles on traffic courts to publications including the Annals of the American Academy of Political and Social Science. He is the author is "Traffic Court Procedure and Administration" (1961), published by the American Bar Association. He is a member of the law firm of Economos and Alexander, Chicago, Illinois.*

SAID a traffic court judge: "Mr. Citizen, this court finds you guilty of the charge against you. Your own testimony agrees in many particulars with the testimony of the state. It now becomes my duty to impose sentence."

This is the moment in every traffic case when the judge feels most keenly how all alone he is on the bench; when he must rely on his experience and training to guide him in arriving at the desirable result in this particular case.

What is the proper sentence or penalty?

What are the objectives of penalization?

What is an effective deterrent in this case?

What factors must be considered?

These and other questions should be answered by the traffic court judge every time he concludes that the defendant is guilty after trial. Of course, he is faced with the same problem every time the defendant voluntarily pleads guilty without the benefit of a full trial.

Just what is a judge attempting to accomplish when he imposes a penalty? What is the nature of the responsibility that is being discharged by the judge? What guideposts does he have available to assist him in this important task? Is it possible for him to measure his effectiveness?

The American Bar Association Standing Committee on the Traffic Court Program[1] has placed a high priority on this aspect of the work of the traffic courts. It called together judges, prosecutors, and court officials for participation in a national symposium on correcting the violator. It was held August 9, 1961, in St. Louis, during the annual meeting of the American Bar Association. Many are awaiting the results of this symposium which will be published at an early date.[2]

In the meantime, it is certain that the principal aim of every traffic court is to correct and educate violators of traffic laws rather than just to penalize them. By the same consideration, it is also difficult to compare the results achieved by individual traffic court judges in the correction and education of violators on the basis of the nature of the penalties imposed.

Evaluating the effectiveness of traffic court penalties is not a simple task. Any attempt in this area requires a serious inquiry into the many elements establishing the environment in which the traffic court is functioning.

Among the important elements are those pertaining to the following:

I. Community Attitude
II. Court Room Atmosphere
III. Traffic Offense
IV. Analysis of Violator
V. Range of Penalties Available

All of the above must be examined carefully before it is possible to make any determination as to the effectiveness of traffic court penalties. Each exerts an influence on the other. These elements

1. Albert B. Houghton, Chairman, Milwaukee, Wisconsin; Roy A. Bronson, Vice Chairman, San Francisco, Calif.; Honorable Tom C. Clark, Washington, D.C.; Hicks Epton, Wewoka, Oklahoma; J. Harry LaBrum, Philadelphia, Pennsylvania; Robert J. Shoup, Cleveland, Ohio; Lowell D. Snorf, Jr., Chicago, Illinois.

2. For further particulars write to: Traffic Court Program, American Bar Association, 1155 East 60th Street, Chicago 37, Illinois.

enter into the judicial crucible and produce the end result—the penalty imposed by the judge.

### I. COMMUNITY ATTITUDE

The community attitude is conditioned by all past efforts to achieve a safer place in which to live through traffic accident prevention activities. These include every educational, engineering and enforcement technique practiced in the community. It requires an inquiry into the community's respect or lack of respect for laws, particularly traffic laws.

The judge must analyze his community with reference to its attitude toward traffic law enforcement. In making his analysis he must remember that he, too, is the product of the community. He should realize that he was conditioned into the attitudes and beliefs of his community as to the kind of traffic law enforcement that was acceptable or tolerated. He must actually make a conscientious effort to evaluate how much the educational process has contributed to this attitude.

For example, is there driver-safety education and behind-the-wheel instruction in high school? Is bicycle-safety education available in elementary schools? Is there training for pedestrian safety among the older adults and for the young school children who may be riding tricycles and kiddie scooters? Is there an active local safety council? Is it maintaining a vigorous program of community traffic safety education? Does the local bar association support the court's program?

The political climate contributes immensely to the community attitude towards sound traffic law enforcement. Are the political leaders supporting a no-fix policy which guarantees no special privilege or favoritism to anyone in the community? Have the clergymen in the community undertaken steps to secure acceptance by the community of its moral responsibility to obey all traffic laws?

Business organizations have an obligation to support adequately, through financing and program participation, better traffic law enforcement. Are the business leaders demanding unfair advantages or are they in favor of equal treatment for all? Civic, fraternal, professional, social, union and women's groups all owe full support to traffic safety and traffic law enforcement activ-

ities in the community. Are they in the forefront of the effort to respect traffic laws?

Every community needs constant reminders that it is necessary and proper to obey traffic laws. The most consistent source for these is the media of press, radio, television and related means of communication. Are the media furnishing these constant reminders through their newspapers, broadcasts and telecasts?

If the answers to these questions are in the affirmative, the judge has a better opportunity to embark upon a program of solid corrective and educational penalization. He has a solid foundation upon which to build such a program.

If any of the answers are negative, then it becomes a more difficult task to achieve the maximum effectiveness for a court corrective educational policy. Then the judge must exhibit the qualities which determine whether he is a *leader* or a *follower*. If the latter, he will be content to take conditions as they are and live with them during his term of office. There is no contribution to the community's benefit which will accrue from this type of judge.

The judge who is a leader sets the pace for the attitude toward this important phase of community living. He gradually molds it to a higher sense of responsibility for obedience to traffic laws. He does this through his policy of penalization, through his public utterances at appearances before the media groups enumerated above and his performance in the courtroom.

This judge doesn't believe that his judicial day begins when he ascends the bench and terminates for the day when he has finished hearing the last case. He is part and parcel of all community effort to improve its respect for traffic laws and traffic safety.

## II. COURT ROOM ATMOSPHERE

Establishing the proper atmosphere in the court room is particularly within the province of the judge. Adjudicating traffic cases and rendering judgment in a manner which will be meaningful to the individual defendant and act as a deterrent to the community's potential offenders of traffic laws is a necessary part of every judge's work.

Therefore, before an individual judge can establish a proper and effective educational penalization policy, he must have all the

necessary judicial tools available to him in order to administer justice in accordance with the National Standards.[3]

In summary, this means that the traffic court must be properly housed with all the adequate physical facilities needed for the performance of administrative, clerical, procedural, penalization processes and other operations incidental to the court. The judge must be conscientiously interested in his work, having participated in specific efforts to acquire more information about his duties and responsibilities in this area through participation in traffic court and other judicial conferences. He must acquire a broad interest in all facets of his work.

The judge's court must be well administered in every respect so that pre-court processes and post-court processing are performed in accordance with the recognized and prescribed standards which are readily ascertainable. Uniform rules governing procedure in traffic cases[4] should be adopted locally if not already promulgated on a statewide basis. The court should adopt the principal procedural rule that joins the traffic complaint with the traffic summons.[5] This will meet the recommendations of the President's Committee for Traffic Safety; the conference of chief justices; the national conference of commissioners on uniform state laws; the public officials traffic safety conference; the national sheriff's association; and the American Bar Association.

The traffic court judge should then take special pains to provide in these rules for the mandatory court appearance of all persons charged with moving hazardous violations. This will place him in line with the key resolution of the conference of chief justices which reads as follows:

"RESOLVED that because of the increasing toll of highway accidents, trial courts of first instance should require all persons charged with moving violations to appear in court in person and

3. See revised and updated Action Program for Traffic Courts approved by the President's Committee for Traffic Safety and the American Bar Association. Write to Superintendent of Documents, United States Printing Office, Washington, D.C.

4. Model Rules Governing Procedure in Traffic Cases, adopted by the National Conference of Commissioners on Uniform State Laws, July 12, 1957, and recommended by the American Bar Association, Traffic Court Program.

5. Uniform Traffic Ticket and Complaint, A Guide Designed to Assist Traffic Court Judges, prepared by the American Bar Association Traffic Court Program, 1155 East 60th Street, Chicago 37, Illinois. Individual copies are available.

the traffic judges should increase the amount of individual attention given to each case of such nature for the purpose of assessing adequate corrective penalties, and that, if necessary, steps be taken to add additional judges and prosecutors to accomplish this end."[6]

Having adopted this fundamental concept, it then becomes necessary for the court to go further and make the personal appearance of such a violator a truly representative and educational experience. Steps should be taken to minimize the length of time to attend upon the court by both the police officers who must appear as witnesses and the persons accused of traffic charges who appear as defendants. A conscientious effort must be made to achieve solid calendar control similar to that recommended and installed by the Metropolitan Court of Dade County, Florida, and other courts in the country.

To adopt this standard means that there must be enough judges and prosecutors available together with sufficient clerical personnel. It further requires an adequate number of court rooms to house each judge and permit the staggering of the case load into shorter court calendars. The latter will provide the judge with sufficient time to give enough individual attention to each person so required to appear in traffic court.

Each of these sessions of the traffic court should follow the recommended procedures of opening and closing ceremonies, opening remarks by the judges on traffic court procedure, rights of the defendant, and explanation of the consequences that will flow from a conviction together with an explanation of the decision at the conclusion of each case.

### III. TRAFFIC OFFENSE

All of the foregoing are conditions precedent to an adequate traffic court procedure and administration which are most essential in the establishment of the policies of corrective and educational penalization.

The circumstances and conditions present in the traffic offense brought to the court's attention represent the first step in the

6. The Sixteen Resolutions of the Conference of Chief Justices represent a vital group within the National Standards for the Improvement of the Administration of Justice in Traffic Courts. These standards were re-affirmed by the President's Committee for Traffic Safety in its revised and updated Action Program for 1961.

penalization process. The nature of the traffic offense, its seriousness and the hazard present will unfold during the hearing on the guilty plea or by the trial of a not-guilty plea.

In each traffic offense, it is possible to establish differing degrees of seriousness. For example, in the model uniform traffic complaint and summons, there are three degrees of seriousness set out as to the six violations appearing in the form following:

SIX PRINCIPAL CAUSES OF ACCIDENTS

| | | | |
|---|---|---|---|
| SPEEDING (over limit) ( m.p.h. in | ☐ 5–10 m.p.h. m.p.h. zone) | ☐ 11–15 m.p.h. | ☐ Over 15 m.p.h. |
| Improper LEFT TURN | ☐ No signal | ☐ Cut corner | ☐ From wrong lane |
| Improper RIGHT TURN | ☐ No signal | ☐ Into wrong lane | ☐ From wrong lane |
| Disobeyed TRAFFIC SIGNAL (When light turned red) | ☐ Past middle intersection | ☐ Middle of intersection | ☐ Not reached intersection |
| Disobeyed STOP SIGN | ☐ Wrong place | ☐ Walk speed | ☐ Faster |
| Improper PASSING AND LANE USAGE | ☐ At intersection<br>☐ Between Traffic<br>☐ Lane Straddling | ☐ Cut in<br>☐ On right<br>☐ Wrong lane | ☐ Wrong side of pavement<br>☐ On hill<br>☐ On curve |

OTHER VIOLATIONS (describe)_____

IN VIOLATION OF the (statute) (ordinance) in such case made and provided.

This breakdown can be made for any traffic offense. In fact, it is necessary to arrive at some understanding as to the differing degrees of seriousness present in every one of the offenses. It is a necessary step preliminary to evaluating the proper penalization in each case.

In addition, it is possible to ascertain the danger incident to each traffic offense. The conditions which constitute greater hazards can also be charted as in the model uniform traffic complaint and summons. This is accomplished through the inclusion of the table on the following page.

Other conditions may also be present and these, too, must be taken into consideration by the judge in evaluating the combined effect as to total seriousness and hazard.

In this area practically all judges can arrive at essential agreement as to uniform minimum fines. In fact, there have been area-wide attempts at such uniformity. This is healthy so long as it is

recognized that this agreement must yield to the analysis of the violator. It is only in this section of the entire penalization process that it is possible to set minimum uniform dollar-for-dollar fines. This, too, performs a useful service because it gives all judges a uniform point of departure when application is made to the individual defendant.

CONDITIONS THAT INCREASED SERIOUSNESS OF VIOLATION

| | | | |
|---|---|---|---|
| SLIPPERY PAVEMENT | ☐ Rain<br>☐ Snow<br>☐ Ice | CAUSED PERSON TO DODGE<br>☐ Pedestrian | IN ACCIDENT<br>☐ Ped. ☐ Vehicle |
| DARKNESS | ☐ Night<br>☐ Fog<br>☐ Snow | ☐ Driver | ☐ Intersection<br>☐ Right Angle<br>☐ Head on |
| OTHER TRAFFIC PRESENT | ☐ Cross<br>☐ Oncoming<br>☐ Pedestrian<br>☐ Same Direction | JUST MISSED ACCIDENT<br>☐ one foot | ☐ Sideswipe<br>☐ Rear end<br>☐ Ran off Roadway<br>☐ Hit Fixed Object |

AREA: ☐ Business ☐ Industrial ☐ School ☐ Residential ☐ Rural

HIGHWAY TYPE: ☐ 2 lane ☐ 3 lane ☐ 4 lane ☐ 4 lane divided

This is more than exists today except in a few situations such as the Metropolitan Court of Dade County where the thirteen judges are in general agreement as to the uniform minimum penalty.

## IV. ANALYSIS OF VIOLATOR

In the course of conducting traffic court conferences over the past fifteen years, it has been possible to evolve a pattern that can be used as a general guide in analyzing the violator. The chart on the opposite page represents the composite viewpoint of many judges from all sections of the United States.

The first factor is the analysis as to the cause of the violation by the defendant. Considered from the standpoint of driver-improvement methods, there are three types of delinquent drivers—the *Can'ts*, the *Dont's*, and the *Won'ts*.[7]

The *Can'ts* are those who because of physical or mental defect are unable to operate motor vehicles properly. In this group are included persons with defective eyesight, defective hearing, and other physical impairments. The mental handicapped are also included.

7. Economos, "The Traffic Problem, Traffic Laws and Traffic Courts." *Annals of the American Academy of Political and Social Sciences*, May, 1953.

Neither a jail sentence nor a money fine will correct any defective physical or mental condition. It will be necessary for the court to require re-examination of the operator to determine the exact extent of the disability. If his defect is not correctable, the judge and driver licensing authority should undertake to bar the driver from the use of the highways.

CORRECTIVE AND EDUCATIONAL ACTION (PENALIZATION)

| | |
|---|---|
| *Circumstances Developed During Trial of Violation* | Degree of Seriousness of the Violation<br>Dangerous Conditions Adding to Hazard the Violation |
| *Finding* | Guilty |
| *Factors Used In Penalization* | |
| *Analysis of Cause of Violation* | Can't: A. Physical B. Mental<br>Don't: A. Rules of the Road B. Skill C. Judgment<br>Won't: A. Respect Law B. Obey C. Improper Attitude |
| *Previous Driving Record* | Prior Convictions of Traffic Laws: A. Local B. Statewide |
| *Age* | Adult<br>Minors Over Drivers License Age |
| *Personal* | Sex<br>Marital Status<br>Family<br>Occupation<br>Economic Condition<br>Education |
| *Court Action* | Fine<br>Days in Jail<br>Both Fine and Jail<br>Probation<br>Court Supervision<br>Traffic School<br>Driver retraining<br>Suspension of License |

Prepared for Traffic Court Conferences by the
Traffic Court Program, American Bar Association

The *Don'ts* are those deficient in one of three respects: they don't understand the rules of the road; they display less than ordinary skill because of lack of experience in its operation; and they lack judgment in the operation particularly with reference to the laws of motion. Here the court can use its ingenuity in supplying the opportunities to eliminate the underlying defect without use of fines or days in jail.

Driver-improvement schools, the writing of essays by students and additional driver's safety education may be suggested. There is a growing appreciation of the need for driver education for adults to improve driving habits, develop additional skill, and correct specific faults. This applies to both older and younger drivers.

The *Won'ts* are those who lack respect for traffic laws or because of a faulty attitude refuse to accept personal responsibility for obeying traffic laws. Their attitude may be due to the lack of uniformity in the enforcement of traffic laws. It may be due to bad handling on the part of the judge, the prosecutor, the clerk, or others serving the court.

It may be due to faulty traffic engineering which is not justified by conditions existing at the time and place, such as low speed limits on modern highways with wide pavements, divided parkways, and no intersecting highways. It may be due to poor police enforcement. The repeaters will most often be found in this group, and here the traditional fines, jail sentences, and license suspensions and revocations can be effective. There can also be effective use of the educational devices mentioned above.

The percentage of *Can'ts*, *Don'ts*, and *Won'ts* is not known exactly. However, the estimates of several judges from widely separated areas indicate that the *Can'ts* should not exceed ten percent, and that the *Don'ts* and the *Won'ts* are about equally divided, with many violators partaking of characteristics applicable to both groups.

In addition to the foregoing analysis, the judge should be supplied by either the prosecutor or enforcement agency with the prior record of the defendant. If possible, this prior record should be the statewide record accumulated by the driver licensing authority. In the absence of the ready availability of this record, then the local record maintained either by the court or enforcement agency should be brought to the attention of the court.

Furthermore, every judge can ascertain the prior record by inquiry of the defendant standing before him in the court room. Obviously, this has some drawbacks although most defendants do not hesitate to readily answer this inquiry of the judge.

The next source of inquiry that must be advanced by the judge is the age of the defendant to determine whether he is a teenager, a young adult, adult, or older driver. This is a characteristic that judges take into account in determining the penalty to be imposed. It is obvious that each age group responds differently to the corrective and educational policy of the judge. The judge must, therefore, set his policies to make them meaningful to each age group.

Finally, most judges state that they are influenced in their determination as to the proper penalty by practically all of the personal characteristics of each defendant such as, sex, marital status, family, occupation, economic condition, education and residence. It can readily be understood that considerable individual attention must be given by the judge to each defendant who appears in the court room in order to ascertain the above information.

The judge's individual attention starts from the time he observes the defendant arising in his seat when his name is called. The judge follows the defendant from his place in the court room as he travels to the required position in front of the bench. He observes his responses to the questions concerned with the arraignment process and the subsequent proceedings on a plea of guilty or the trial that follows a plea of not guilty.

These observations are supplemented by the comments that the defendant may make in response to the judge's request for any comment prior to the imposition of sentence. During this interval, the judge can add other characteristics present in his analysis of the defendant. From all of this, he arrives at his determination of what is the proper corrective and educational penalization.

Many judges have stated that they have relatively no difficulty in arriving at the determination of guilt or innocence of the defendant. On the other hand, they feel so completely alone when it comes to making their decision as to the proper penalty. They must be vigilant not to fall into the trap of applying assembly line justice.

Since they ordinarily do not have the benefit of the pre-sentence investigations which are made available to them in criminal matters, they must give sufficient individual attention to each case to

arrive at what must be fair from the standpoint of determining the proper penalty.

Fortunately, most traffic court judges are developing policies which enable them to apply the range of penalties available to them to the various types of defendants appearing before them.

All efforts at correction and education of the defendant analyzed as above must be limited somewhat to the authorized penalties.

### V. RANGE OF PENALTIES AVAILABLE

The judge's first concern is to ascertain the range of penalties available to him and the amount of discretion afforded by the state legislature and the city council. For example, the Uniform Vehicle Code[8] sets out the range of penalties in Section 17-101 which reads as follows:

"Penalties for misdemeanor:

"(a) It is a misdemeanor for any person to violate any of the provisions of this act unless such violation is by this act or other law of this state declared to be a felony.

"(b) Every person convicted of a misdemeanor for a violation of any of the provisions of chapters 10,[9] 11,[10] 12,[11] 13,[12] or 14[13] for which another penalty is not provided shall for a first conviction thereof be punished by a fine of not more than $100 or by imprisonment for not more than ten days; for a second such conviction within one year thereafter such person shall be punished by a fine of not more than $200 or by imprisonment for not more than twenty days or by both such fine and imprisonment; upon a third or subsequent conviction within one year after the first conviction such person shall be punished by a fine of not more than $500 or by imprisonment for not more than six months or by both such fine and imprisonment.

"(c) Unless another penalty is in this act or by the laws of this

8. Prepared by the National Committee on Uniform Traffic Laws and Ordinances, 1604 K Street, N.W., Washington 6, D.C. The revised 1956 edition may be obtained by writing to them or to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C.

9. Chapter 10, refers to Accidents and Accident Reports.

10. Chapter 11, refers to Rules of the Road.

11. Chapter 12, refers to Equipment of Vehicles.

12. Chapter 13, refers to Inspection of Vehicles.

13. Chapter 14, refers to Size, Weights, and Loads.

state provided, every person convicted of a misdemeanor for the violation of any other provision of this act shall be punished by a fine of not more than ($500), or by imprisonment for not more than six months, or by both such fine and imprisonment."

Section 17-102 sets forth the penalty for a felony and provides that conviction for such is by imprisonment for not less than one year and not more than five years or by a fine of not less than $500 nor more than $5,000.

This general penalty provision has its counterpart in all states where the Uniform Vehicle Code has been adopted and in many others which do not substantially conform to the Code. The offenses which normally receive specific penalty under the Uniform Vehicle Code are leaving the scene of an accident where death or personal injury was involved;[14] reckless driving;[15] driving while under the influence of intoxicating liquor or drugs;[16] and negligent homicide.[17]

These general and specific penalties represent the traditional money fines and days in jail, or a combination of both, which have been established for court action in disposition of criminal matters. In traffic cases, there has been developed an additional penalty of suspension of drivers' licenses by the court.

This, of course, is different from a suspension of a driver's license which results from a poor driving record and is a power exercised by the driver licensing authority. Other forms of court action are in the nature of court supervision which embraces the ordinary continuance for the purpose of pre-sentence investigation, the conditional judgment, probation, suspended sentence with conditions imposed. Among the most popular conditions imposed is that requiring attendance at a driver improvement school or traffic violators' school.

The purpose behind this is obvious. It provides further instruction to the defendant who happens to need it in the judge's opinion. Up until most recent times, driver improvement schools were available only in the more populous cities. Over the years, approximately 100 cities have established and maintained such schools.

No two schools are conducted in exactly the same way. County-

14. Uniform Vehicle Code, Sec. 10-102.
15. Uniform Vehicle Code, Sec. 11-901.
16. Uniform Vehicle Code, Sec. 11-902.
17. Uniform Vehicle Code, Sec. 11-903.

wide driver improvement schools have also been established to meet the needs of several rural courts each unable to support such an enterprise alone. The reported results justify extension to all rural counties.

There are extra-curricular penalties that have been used by some judges such as visits to the morgue, visits to the fracture ward of a hospital, assignment to the work gang for tasks such as cleaning police cars or caring for the lawn or landscaping of the Municipal Building, or assignment to a teenage traffic court. This list could be extended if all the ingenious methods for attempting to correct and educate violators were to be set forth. The range of penalties, therefore, restricts and circumscribes the action of the traffic court judge.

When he imposes extra-curricular penalties, he can only do it with the consent of the defendant. Sometimes, this consent is coerced with the threat of a higher penalty if it is not readily forthcoming. It is within this framework supplied by the legislative bodies that the judge must work to accomplish correction and education of the violator.

There are many advocates of uniform fines and penalties in traffic cases. It must be thoroughly understood at this point that this uniformity can only be outlined in the sense of producing the uniform minimum fine schedules heretofore discussed which can act as a guide to the judge as the result of evaluating the degree of seriousness and the dangerous conditions which add to the hazard. At this stage, it is wise to look to the national standards for further guidance. The Warren recommendations[18] provide little on this subject.

On the other hand, the conference of chief justices of state supreme courts in 1951 adopted the following resolution germane to this subject:

"RESOLVED that fines and penalties for each offense, insofar as possible, should be uniform throughout a state and should be in proportion to the grade of the offense. Consideration should, of course, be given to the number of offenses committed by a particular

18. The Warren Recommendations are number 38, 39 and 40 which read as follows: "(38) Rigid and set fines (as distinguished from flexible standards) for the various traffic violations are to be discouraged. (39) The utilization of effective methods other than fines and sentences for the punishment and treatment of traffic violators, should be discouraged. (40) The primary aim of the traffic court should be to impress defendants with the need for traffic law observance rather than to penalize."

defendant. In flagrant cases, or for repeated offenses, a driver's license should be suspended temporarily or revoked permanently."

Six years later the public officials traffic safety conference on December 10, 1957, adopted the following pertinent long-range need:

"That fact finding studies be undertaken on the effectiveness of present fines and penalties as to their corrective value, the proper use of probation, court supervision, and handling of repeater violators."[19]

The viewpoint expressed in the preceding recommendation was adopted by reference in the recently revised and updated action program of the President's Committee for Traffic Safety. The national symposium on how to correct a violator is the first meeting devoted exclusively to the objectives of finding the facts.

So far, we have considered this problem from the standpoint of the legislatively authorized range of penalties, and from the standpoint of the judicial application of these penalties. The legislative declaration should be a composite of what all drivers think is a proper range of penalties. The judicial application should be a composite of what all judges think.

Finally, testing them against drivers' reactions will determine their effectiveness. If the drivers are impressed that these are fair, impartial, honestly applied policies of penalization, there will be a cooperative response. If there is an unfavorable response, each judge should seriously undertake a self-analysis of the policy to find the cause for their lack of acceptance by the drivers.

The acid test is that of the motoring public passing judgment on the court's penalization policies. This is evidenced by the manner in which they observe or fail to observe traffic laws. For example, there are a number of illustrations around the country where a coordinated program by the police, prosecutor, and judge has resulted in a certain and consistent policy of penalization. Motorists who approach such a community immediately and conscientiously change their habits of driving and keep them changed until they leave the jurisdiction of that particular court.

Thereafter, they resume their disrespectful driving habits. What

19. They also adopted the following recommendation: "That legislation providing for suspension of drivers license be incorporated as an additional remedy available to traffic courts for traffic violations other than non-hazardous violations."

is needed is that more communities join hands in making every community a place which demands proper driving habits. Judges in concert can accomplish this objective. The most effective traffic court penalty, therefore, is the adoption of an intelligent program of correction and education. To accomplish this objective it is absolutely necessary that:

1. All judges require all defendants charged with moving hazardous violations to appear in court in person to answer the charge;

2. That more individual attention be given to each defendant; and

3. That each defendant receive a corrective and educational penalty designed to meet his needs and still present a community deterrent.

It can readily be seen that the establishment of a corrective and educational penalization is a complicated one. There is no categorical answer to what is an effective traffic court penalty at this time without further research.

# New Rapid Transit Planning

LESLIE TASS

*Mr. Tass, former Chief Engineer of the Hungarian Ministry "Város és Községgazdálkodási Minisztérium" left his native country in 1956. Now residing in Canada he is working in the construction business. He had developed modern principles of rapid transit in Budapest, and continued these studies in Toronto. This article presents ideas leading to a new way of rapid-transit planning. His thesis in this essay is that only the most efficient rapid-transit systems are able to relieve the street congestions of great cities. Mr. Tass received his diploma in Civil Engineering from the Joseph Nador University of Technical Sciences in Budapest in 1938. He is a professional engineer registered in the Province of Ontario. He is a member of the Engineering Institute of Canada.*

THE history of rapid transit began with the first underground railway built under London streets in 1863 connecting three railway stations. It was 3.5 miles long. Steam engines and standard railway coaches were used; the only difference when compared to surface railway lines was that it was constructed underground, and was wholly separated from surface traffic. This feature is the first and one of the most important conditions of rapid transit lines.

The construction of this line was suggested by Charles Pearson to avoid street congestion. It may appear strange to use the term street congestion at that time, but the future need for such a line was well foreseen.[1] At a certain point of evolution, every big city is faced with the same problem.

## THE LIVING CITY

A city is rarely constructed at once; it has a long evolutionary growth. Cities usually appear on the bank of a river or on the shore of the sea, providing harbour facilities, protected against storms, and often on an island or peninsula offering natural protection against attack. For this protection, settlements in Europe were surrounded also by heavy walls, as in Quebec City.

The birthplace of New York, as well as of Toronto, was on spots especially useful as well-protected harbours. Montreal has been

1. Howson, F. Henry: London's Underground, 1951.

developed on an island. Paris developed around the islands of the Seine. Berlin's life started at the island of the Spree River.

The growth of cities did not end at the protecting walls. The development of the city requires more and more area for dwelling as well as for business. Development of industry and manufacture gave an impetus to the growth of large cities. The growth appears around the nucleus primarily in the directions of and along the main routes leading to the middle of the city. The center—formerly often walled—became downtown, comprising the important buildings and establishments forming the central business district.

The development of the city is marked by changes of quantities, and population increase is the basic measure of city development. More people need more dwellings, so residential and other areas grow with the increase in population. There is, as well, a qualitative development. Small homes change to apartment buildings, shops to factories, and as the density of population rises, new projects and important establishments come into being. The wealth and power of the city rises with its growth.

Meanwhile the traffic situation changes. This change, again, has two faces. The number of streets, traffic lines and length of lines all increase with respect to quantity. The quality of kind and method of conveyance changes as well. Horse trams, electric street cars, buses and subways mark the milestones of city transit development.

The traffic system spreads farther and farther over the city. The heart of the living city is the central business district. To maintain the healthy growth of the city, transportation must provide the most efficient flow of goods and people to and from the heart of the city.

## EVOLUTION OF RAPID TRANSIT

Great cities, generally above one million population, usually require underground transit lines to relieve surface street congestion. The construction of these subway lines usually starts with the most overcrowded streets. Subway service has been developed from railway service, gradually improving its features and leading finally to rapid transit.

The first subway line of London was only a railway placed un-

derground and later extended and slightly improved. Other lines were constructed by other companies, creating healthy competition. In a way, this competition obstructed the evolution of modern rapid transit. Companies acted primarily in their own interests, not in concert. For a long time, the importance of a general plan developed on sound town-planning purposes was not realized. Seventy years elapsed before the London system was unified and placed under public ownership.

The Metro subway of Paris was planned by the government. The 1898 plan included five lines only, and only two of the five served the central area. Next stages included extensions and other lines, constructed mostly under the streets, resulting in intricate alignments. The network covers the whole Paris area, but not in the way efficient modern systems do.

The need of the times to keep expenses at the lowest possible level impeded the development of principles of modern rapid transit. The improvements, developed step by step, together giving the features of rapid transit service, are listed in the following table:

CHARACTERISTIC FEATURES OF RAPID TRANSIT SERVICE

| *Feature* | *Means* | *Notes* |
|---|---|---|
| Free way (separate level) | Usually underground | 1863 London |
| Adequate facilities | Electric motorcoaches | 1896 Budapest |
| Quick change of passengers | Level platform<br>Adequate car doors | Short traveling time (short standing time, short running time) |
| Performance | Speed<br>Acceleration<br>Capacity<br>Time schedule | Many passengers carried within short period |
| Good connections with surface traffic | Well located stations, escalators, etc. | Short access time |

In the past, these features were considered the criteria of rapid transit systems. In general, anywhere a subway line was established, it was considered *rapid transit*, having the great advantage of higher speed in comparison with surface traffic.

Constructing one line after the other, the great cities developed certain networks.

The early London and Paris subway lines were constructed under the streets, and as a result the network developed was similar to

the surface street networks. The structure of the network was not intensively studied at that time. The aim was to gather as many passengers as possible.

For this purpose lines were constructed connecting districts not yet having subway lines, without taking shape or role of lines into consideration. As lines usually intersect each other, this basic form of network was called "cross system."

For the purpose of connecting as many districts as possible, chiefly residential districts, circular lines were constructed. The

Figure 1. Typical Passenger Flow to the Central Business District

system thus developed is called the circular system. The Glasgow system consists of a circular line having an average diameter of two miles. Vienna has a circular line.

Neither of these has been developed to an up-to-date system.

Other cities—New York, London, Tokyo—have constructed new lines, one after the other. The problem of city transportation has been intensively studied and a close connection is now found between transit systems and town planning.

### TOWN PLANNING AND RAPID TRANSIT

City traffic has characteristic features which were observed while the traffic, the directions and length of trips, and development of the city were systematically studied at the same time. It was found that most trips were in the directions of main traffic lines heading to the city center. These directions are the directions of primary desires. Eliminating the directions of secondary desires, the passenger flow of a schematic city is shown in Figure 1. Along these directions most riders go to or through the city center; thus the passenger flow, coming from any direction, grows gradually approaching the center.

Traffic lines, placed in any directions, which are actually the main traffic arteries of the city center, are called main or trunk lines. The purpose of these radial lines is taking the most important traffic desires to or through the city center.

Other desires are served by lines in other directions. Such lines connecting districts excluding the city center are called secondary or mediator lines. The roles of these lines are of two kinds: connecting districts outside the city center with the main lines leading to the center (loading the passenger flow of main lines), and diverting the flow of passengers who need not go to the city center away from the center (discharging the flow of main lines). The action of the main (trunk) lines has *collector* features, while the other lines do *mediator* work.

An interrelation between town planning and transit lines was found at the beginning of this century. Development of the city brings about the erection of transit lines, and, vice versa, the traffic lines enhance development of the city. The better and the more effective the transit system is, the greater is the effect on the development. Thus the rapid transit system, being the most effective of traffic lines, has the greatest influence on city development if it is really a rapid transit system.

The term *real rapid transit* is the answer to why some rapid transit

lines had a great effect on city development, while other lines retarded development of the system itself.

It was found that not only the direction of lines is important, but also their sequence of construction. It was found that alignment of trunk lines is the most important criterion of their success, and slight detours may jeopardize their success.

These observations were gathered by town planners and transit developers but were often disregarded while "conservative" principles and ideas were clung to. For the sake of the best city transit, let us briefly examine the conditions of the modern rapid transit systems.

### RAPID TRANSIT ALIGNMENT

It is obvious that a rapid transit line should carry the most passengers in the direction of the greatest desire, offering the greatest speed possible. This means the line serving this purpose should be straight, or nearly so. The principal question is exactly where the line should be placed.

Theoretically, let us take as a basis the simplest and most natural, as well as the most regular shape, of a city, which is a circle. Most settlements are developed around the core in the form of a

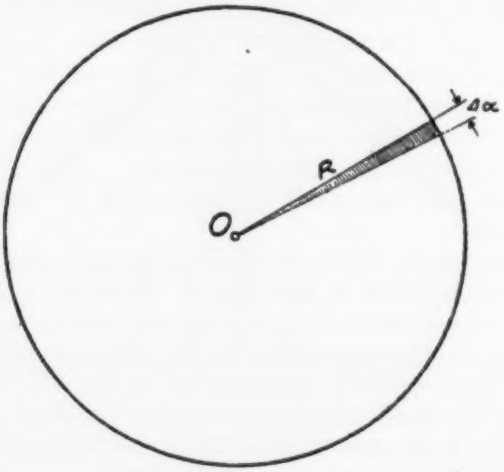



Figure 2. Constant desire. Centrical Origin: $\Delta A = \frac{R^2}{2} \text{arc } \Delta \alpha$ ; invariable desires in any direction.

circle. Let us suppose this surface is uniformly developed, i.e. the business places and residential buildings are uniformly distributed over the area. By these criteria, the riding desire regarding any unit of the area is the same over all the area. The desire in a certain direction is in proportion with the areas affected in this direction.

Let us begin in the center of the area. If we sweep over the area with our radius vector "R," as shown in Figure 2, the $\Delta\alpha$ small angle obviously covers the same area in any direction. Thus, as a result, looking from the center, all directions are equally important, having equal quantities of destinations.

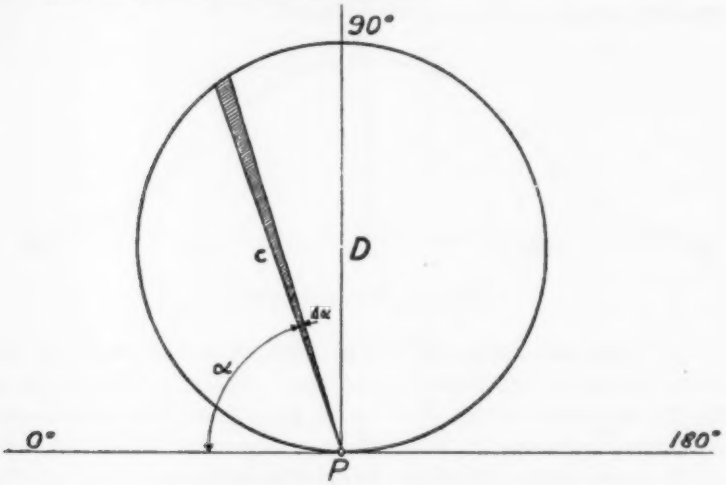



Figure 3. Variable $\Delta A$ Desire Area. Peripheral Origin:

$$\Delta A = \frac{c^2}{2} \text{arc } \Delta\alpha \; ; \; c = D \sin \alpha.$$

Let us start now from the outside, e.g. at the peripheral point "P" as shown in Figure 3. In the tangent direction there is no area affected. Circling over the area from 0° to 180° the radius vector describes within the $\Delta\alpha$ angle progressively larger, then smaller areas, culminating in the direction through the center of the city. The $\Delta$ area, described by the radius on $\Delta\alpha$ angle, varies by the square of c and by sinus as well. This area is the actual measure of desires, its diagram is like a bell curve, as shown in Figure 4. Thus from any outside point, the most important direction is that going

through the center of the city having the highest destination in this direction.

However, destinations are never uniformly distributed over the whole area. In every city there exists a center frequently called "downtown" or "central business district." The attraction of this central area is considerably higher than that of any other part of the city. Thus the destinations concentrated by the attraction of this central area distort the diagram, as shown in Figure 5. (For the rate of this distortion here are two figures. The average destination of street car and bus riders in Toronto is about twenty persons an acre. Computing separately the central business district the attraction mounts to 300 persons an acre.)

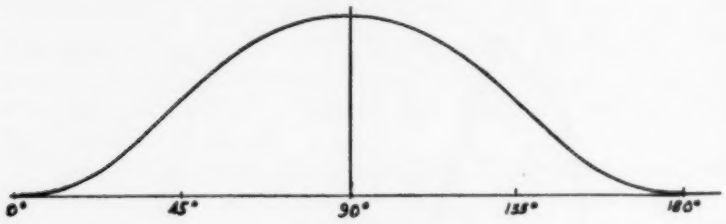



Figure 4. Desire Diagram.

The diagram shows that the greatest attraction, and thus the correct location for a rapid transit line is expressly *in the direction of the city center* and vicinity. Not too far away from this direction the attraction drops rapidly. This is the reason some subway lines, built off the main-desire directions, failed and have never become real rapid transit lines.

As a theoretical result it is found that the alignment of rapid transit lines should connect the center, and—running in any straight lines—the outer part of the city; which means "radial" lines should be used. Practically, the lines usually keep to some main traffic lines which have been developed through the centuries connecting particular areas or other traffic centers with the city center by the shortest route.

Theoretically all radial lines should run to the center point. However, having more than two lines, a multiple connection occurs which is not desirable for two reasons: by the big transfer activity

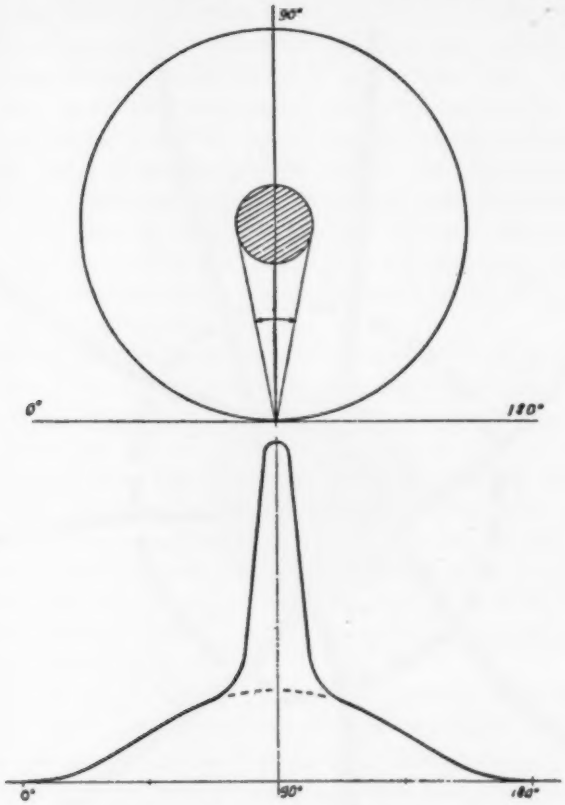


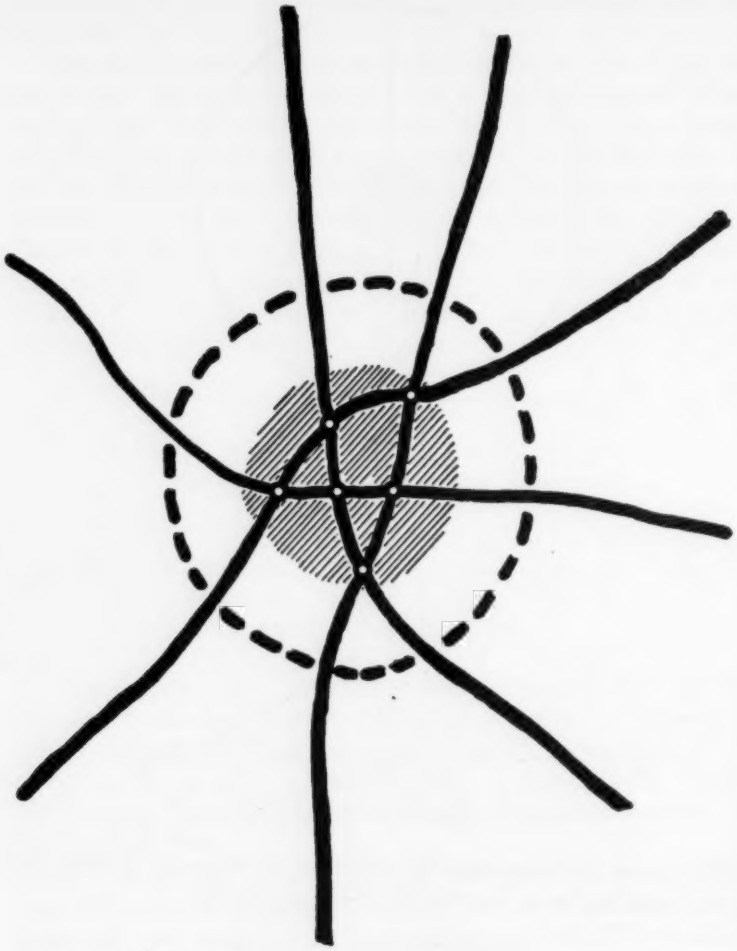

Figure 5. Corrected Desire Diagram.

at this point; by requiring all riders to use this sole interchange point, resulting in an overload in the central area.

### DEVELOPING RAPID TRANSIT

Thus it is desirable to separate interchange points omitting multiple connections. Otto Blum, one of the first developers studying the connections of rapid transit and town planning,[2] suggested an "ideal" structure of networks which is shown in Figure 6 by full lines. The interchange points are well distributed over the city

2. Blum, Otto: Stadtebau, 1937.



Rapid Transit System by O. Blum

Circular Mediator Line

Figure 6.

center (shadowed). For further relief of the center—when considerable circumferential or transversal desires occur—a circular line may be used (dotted line in Figure 6) as mediator line.

Let us now see the contrasts between the conservative bases of subway planning and the principles of modern rapid transit planning. The differences are shown under seven paragraphs.

1. *Scope of planning:* In the early days of subway construction, studies made prior to construction were concentrated usually on one line. The network in most of the early structures was developed line by line, constructed for various reasons and by different companies who had different ideas.

To harmonize the lines of system a *previous general plan is essential.* This is one of the main criteria of modern rapid transit systems. The plan must be in accordance with modern town planning and traffic system principles.

2. *Use of existing traffic routes:* Actual surface traffic lines often were used for subway alignments in the past. The desire on a route already used for transit has evidently been proved by the existing passenger flow. However, the fact has rarely been taken into consideration that the passengers use certain surface routes, not that this actual route is needed, but by compulsion they use routes to reach their destination.

To obtain a clear picture concerning the real desires of passengers, the Origin-Destination survey supplies reliable data. But in the past this survey was rarely made and when it was (e.g. Toronto 1956) its useful information was disregarded. The information provided by O-D data, regarding the directions of desires, usually agrees with the demands of future town (traffic) planning requirements.

It has been proved that there is no reason to adhere to the alignment of existing surface traffic lines if there are possibilities for better alignments. The greatest advantage of subway lines is the possibility of complete freedom in any direction. There is no compelling reason to forego the best alignment of rapid transit lines independent of surface traffic lines.

3. *Construction expenses:* Early subway construction sought the cheapest way of construction, taking into consideration the profit of the business. As far as rapid transit is concerned, this idea was

completely mistaken. The rapid transit system is not a business; it is a utility, a part of the city, actually the most important traffic artery.

It should be erected, therefore, in a manner which provides the greatest efficiency for mass transportation and for city development. Expense must not be unduly limited and must not obstruct the construction of the needed alignments. Construct the best alignments possible—that is not a desire, but a *must* for real rapid transit systems.

4. *Financing costs:* Financial problems were often basic criteria of subway constructions. The financial balance, the warrantability, was the basis of planning in the time of ruling conservative ideas, deeming the subway to be a self-supporting business or even a profitable one.

It was found, however, that the investment of certain lines, needed for real rapid transit routes, was much too high over a reasonable warranty level. In many cases, expensive real rapid transit lines were replaced by cheaper construction on other alignments. The conservative ideas of businesslike subway constructions have now been proved erroneous.

Modern rapid transit systems are built on the *basic criterion of sound city development planning*, provided with the best traffic conditions in the main directions, which also include the possibility of further extensions. In this way, the system designed may not show the best financial results for the present, but provide for continuous progress in city development and passenger flow, insuring the best service and financial results in the future.

For the purpose of erecting a modern rapid transit system, costs should be shared by the company or commission which operates the system and by the city or government whose interest it is to provide the most efficient rapid transit lines for the advantage of city residents and for the sound development of the city.

Taking into consideration that the lifetime of rapid transit systems is over a hundred years, planning, alignment and construction must fit this period. There is certainly no doubt that well-established radial lines will never become obsolete, while many old subway lines in London, Glasgow, Budapest and Paris are already regarded as out-of-date.

Figure 7.

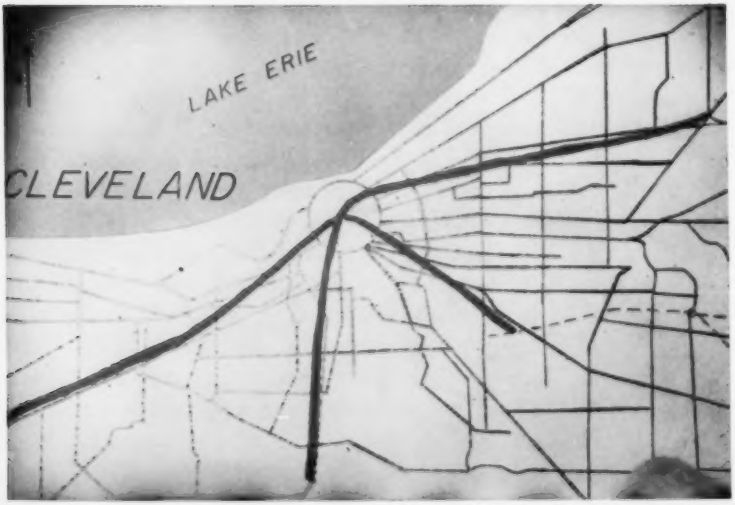



Figure 8.

5. *Compromises:* Compromise solutions were used in some cities for the purpose of constructing one line only in place of two. Figure 7 shows Cleveland's actual subway system where the rapid feature has been lost by the detours of curved lines.

Real rapid transit does not tolerate compromises. The straight alignment of trunk lines must not be altered. Where two lines are needed, both should be constructed simultaneously or one after the other. Figure 8 shows Cleveland's real (ideal) rapid transit system. Any alteration of the required shortest routes jeopardizes the rapid transit feature.

6. *Distinguishing roles:* In the time of early subway constructions, the importance and the characteristics of the routes were not studied. Any line put underground was called "rapid transit." The rapid transit feature depends not only on the underground location, but on the alignment as well. Many subway lines have been constructed which have proved to be "street car lines put underground." A five-mile ride on the Paris subway requires nearly half an hour while on modern rapid transit lines it requires only fifteen minutes.

Figure 9 shows unreasonably curved lines of the Paris subway which are neither radial nor circumferential. For comparison, Figure 10 shows the most modern Moscow system consisting of six radial lines and a circular one (mediator) which are properly established for their roles within the system.

Sequence of the construction of lines is also important. Radial trunk lines should be constructed first. Mediator lines should never precede construction of trunk lines.

7. *Traffic estimates:* Existing, measurable passenger-flow data were often used for traffic estimates in planning a subway. These data do not give as correct information as the O-D survey. Even the latter, highly regarded as reliable, sometimes fails to give complete data as a basis for modern rapid transit system planning. Many riders join the transit system because of its efficiency who were not measurable in flow data based on passenger census. As a matter of fact, a well-placed rapid transit line takes more riders than generally anticipated because of its attractive features. The value and the success of a new line may be measured by the *number of new riders.*

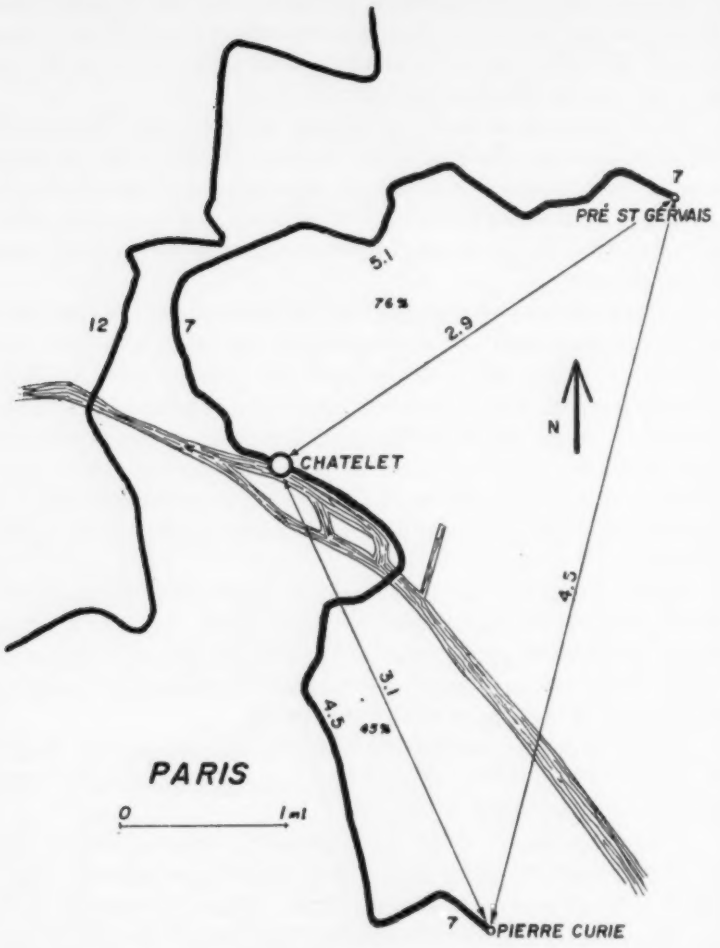



Figure 9.

This attraction may raise the estimated passenger-flow by ten to twenty-five percent on routes which existed before on the same alignment, and by twenty to fifty percent on routes which did not exist before on the surface, e.g. on diagonal rapid transit lines in a city having a squaremesh surface traffic system.

To gain as many new riders as possible, taking them from surface traffic, is a primary aim of rapid transit. In doing this, besides providing mass rapid transportation, rapid transit renders the city another important service by relieving street congestion. This relief is most important on overcrowded surface streets leading to

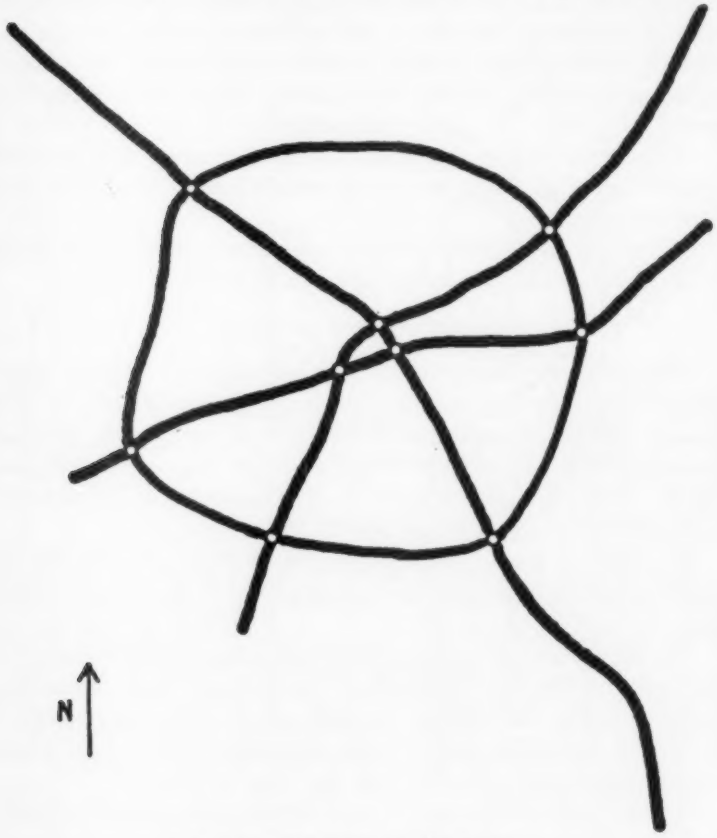



Figure 10. Moscow R. T. System.

city centers. Thus the alignment of radial rapid transit lines is more important than the location of mediator lines whose attraction is, in any case, considerably lower than that of trunk lines.

Developers in the past often took into consideration the total

number of riders using a certain line without examining the characteristics of these trips. Some mediator lines carry many passengers short distances only, e.g. Toronto's Bloor line. Short trips, and considerable difference between figures of total riders and passenger flow are characteristics of mediator lines, while trunk lines show long trips and no great difference between total number and highest flow of passengers. Mediator subway lines carry passengers who formerly used surface transit facilities, while trunk lines take, in addition to existing surface riders, many other new passengers as well.

It is the mission of the subway to provide new, efficient traffic routes (first of all, short trunk lines) which cannot be erected on or over the surface.

These are the paths of modern rapid transit planning, following the directions of sound, far-seeing town planning.

### THE TORONTO EXAMPLE

The foregoing items prove that the original "conservative" ideas concerning rapid transit systems are already out-of-date. The modern theory of rapid transit is based on completely different principles. After the failures of "conservative" subways, and following the success of modern rapid transit lines there is no doubt which way is correct in rapid transit system planning.

In addition to the above-mentioned principles of modern rapid transit planning, there are other details to be taken into consideration.

Passengers usually do not like transfers because of their inconvenience; nor do they like detours, due to loss of time. Therefore, planning should be balanced in these respects. The experience of modern rapid transit systems shows that the system, based on the foregoing principles, also fits these last requirements.

The best criteria of a rapid transit system is contained in the following statement by the Metropolitan Toronto Planning Board: "*The subway should carry as many passengers as possible, as far as possible, on the most direct route, and with the greatest saving of time. In particular, it should serve as efficiently as possible the Central Business District.*"[3]

It is a strange coincidence and a great pity as well that the fine

3. Report on East-West Rapid Transit and Expressway, 1957.

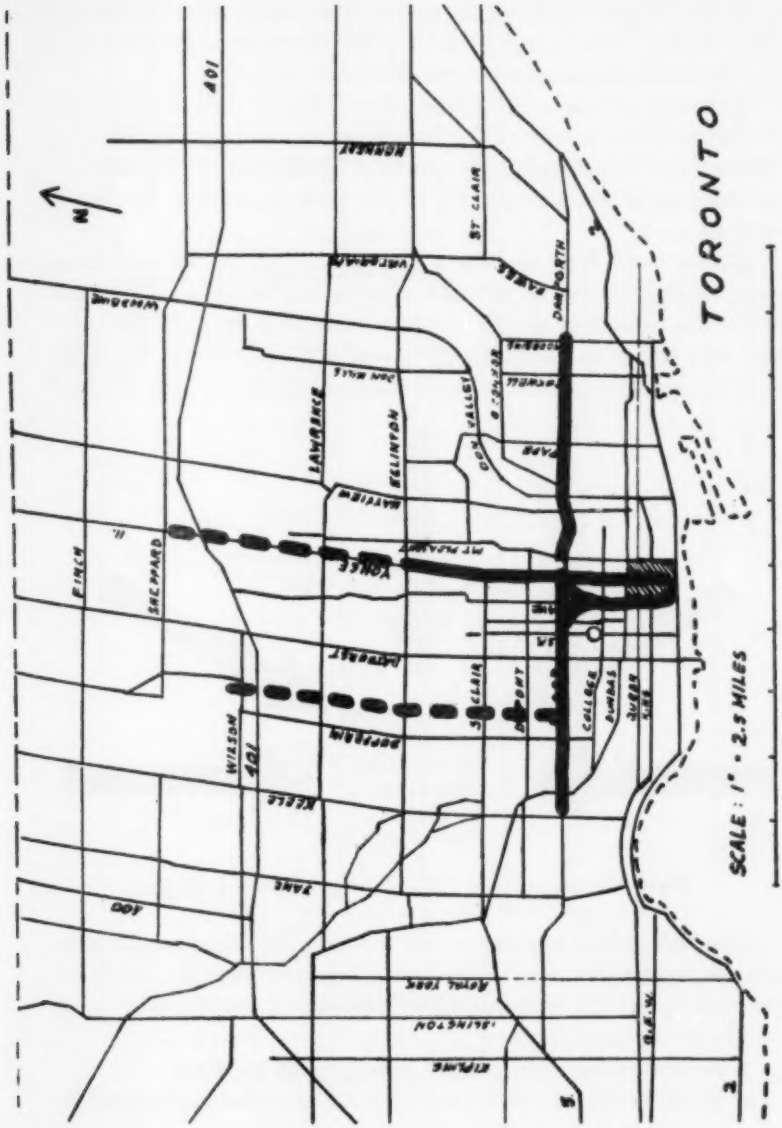



Figure 11. Subway Lines Planned by T. T. C.

instructions of these criteria were completely disregarded in the same city. Figure 11 shows the present plan of the Toronto Transit Commission. It is conspicuous that the downtown (shaded) area has direct connections in a north direction only.

Other plans show the "Queen-Pape" line as well, but the construction of two parallel E-W lines is not recommended. The new "Bloor Line" now under construction—E-W line on Figure 11—provides no direct connections to the most important downtown sections.

Between the East and West ends connected by the new Bloor Line, there is almost no actual transit desire, while downtown actually has desires of nearly 100,000 daily trips in E-W direction and over 50,000 in diagonals (NW and NE), Figure 12. To satisfy these desires, another system such as shown in Figure 13 is needed.[4]

Figure 12. Main Directions of Transit Rider Desires.

The Bloor Line represents the conservative ideas which have been disproved. It is easy to see on the Toronto example. There are four main purposes jeopardized by misplacing rapid transit lines.

The well placed line:

1. Results in best efficiency of rapid transit services.
2. Provides the most direct route for the most passengers possible.

4. Report on Toronto's Rapid Transit System, by author, 1960.

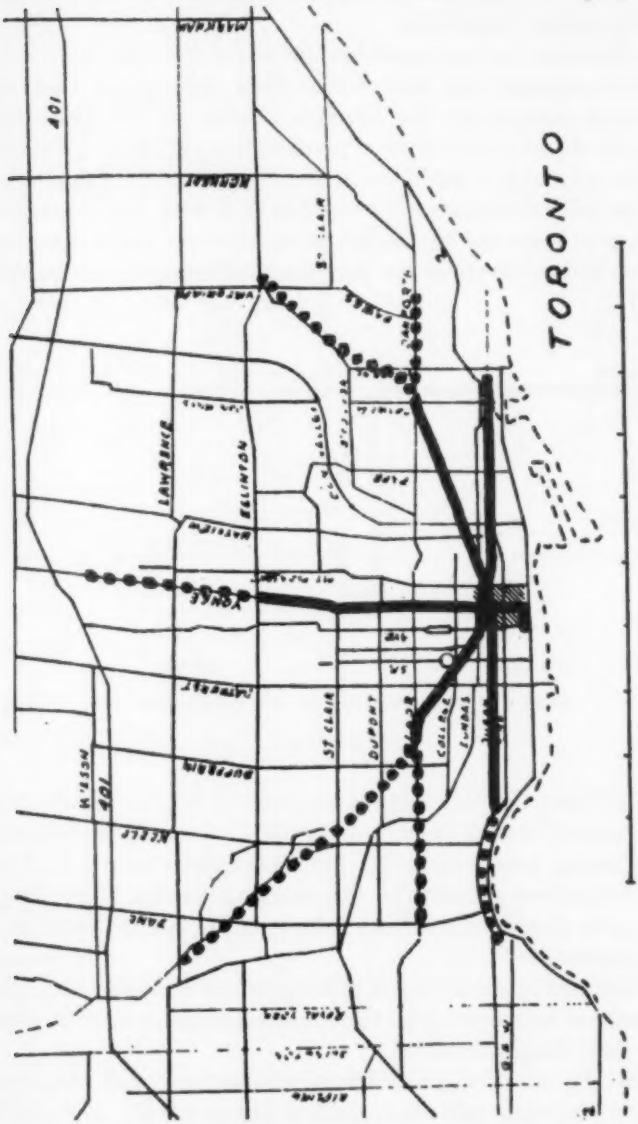



Figure 13. Main Lines of Toronto's Rapid Transit System.

3. Takes as many new passengers as possible, giving the highest relief to surface congestion.

4. Provides the best conditions for city development.

Let us compare the desired *most direct routes*—light lines—with the routes planned by the Toronto Transit Commission—heavy lines—the differences in their actual lengths are shown in Figure 14.

The area which is to be primarily served by rapid transit stretches from Ossington to Coxwell in W-E direction. These intersection points are the best locations on Bloor for rapid transit connections to downtown for the purpose of relieving Bloor congestion as well.

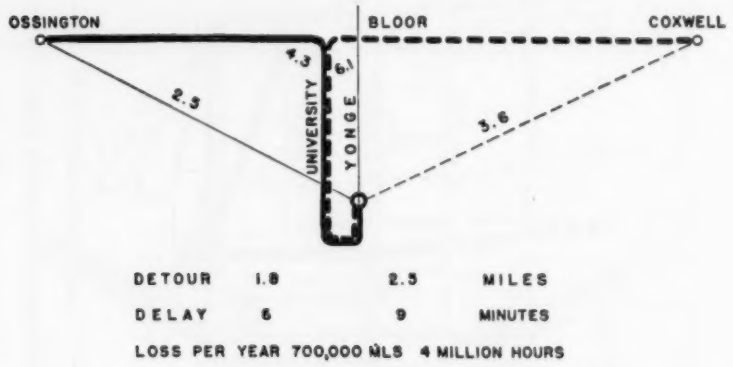



Figure 14.

Concerning the four items mentioned above, the results in the present case (Toronto Transit Commission plan) are the following:

1. Coming from west to the city center, there occurs a 1.8 mile detour while from the east the difference is 2.5 miles. These detours mean more than a half-million subway miles more a year for the transit commission.

2. Taking the loss of time of passengers into consideration, riders lose 4 million hours yearly by these detours, which would be gained on the short diagonal routes.

3. By the use of short, diagonal connections with the center, many people would join the rapid transit system who used cars before. The estimated number of these people is about 16,000 daily,

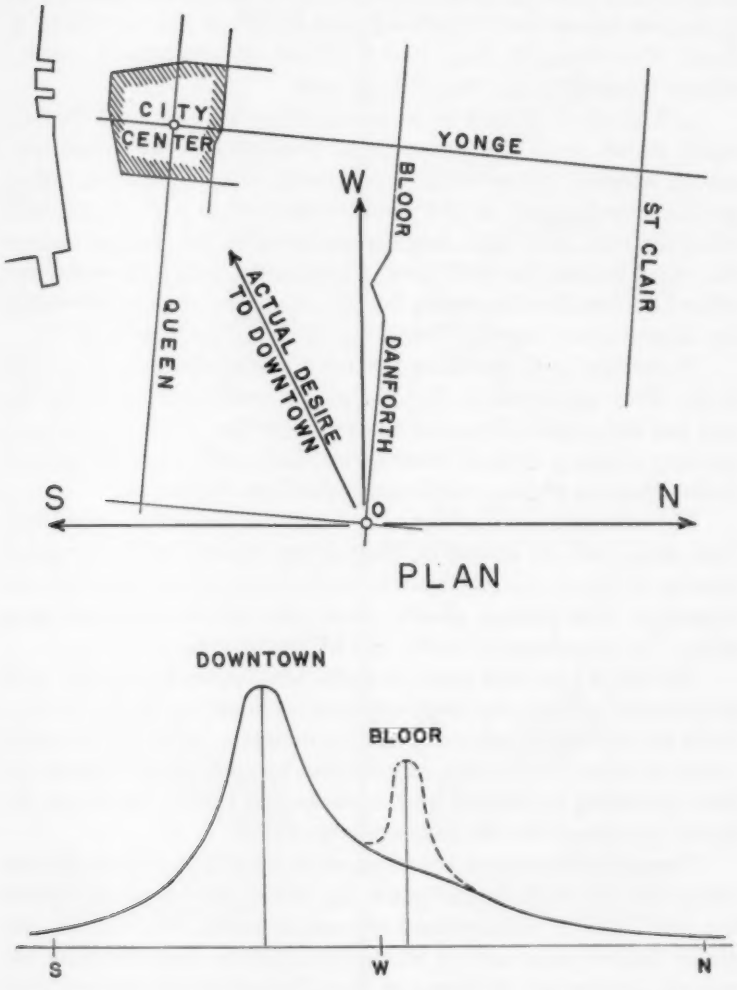



Figure 15. Desire Diagram on Point "O"

which means about 10,000 cars less entering the downtown area. That would provide considerable relief to downtown streets, and 2,500,000 square feet of parking area would at the same time be freed. The detoured lines, which attract few passengers, neither relieve congestion nor free parking area.

4. Though it is hard to measure, it has been noticed that the rapid transit services which provide the best traveling conditions on the shortest routes to the city center bring about an earlier, greater development of the districts affected in comparison with other districts. The high development of affected districts endows the rapid transit line with great significance, while detoured and other lines not directly serving the city center remain lines of secondary importance—merely "street car lines put underground."

Regarding town planning problems, the most important result of the Bloor-alignment is that the center point of the subway system has been moved from the city center to the Bloor-Yonge intersection, where a second "new downtown" will be developed. A desire diagram of this actual case is shown in Figure 15.

The new desire of the "new downtown" is shown by dotted line. This desire will be served by the subway system, while the great existing desire in the direction of the real downtown has been disregarded. This picture clearly shows the failure of conservative ideas. The remainder of traffic will be lost as well.

The Bloor Line will result in many new desires facing the "new downtown"—shown by longitudinal shaded arrows in Figure 16—while the burning problems of existing desires—cross shaded arrows—are not solved. Thus this conservative way results in unbalanced town planning conditions and uncontrolled traffic situations, followed by a troubled city development.

Toronto's Bloor Line is just one of the many flaws, from the new viewpoints of rapid transit planning, which have happened since the first London underground was constructed. Nevertheless, the earlier failures most always warn developers to keep the most advanced modern way of planning, avoiding old-fashioned solutions. Metropolises do not need just traffic lines put underground, but do need the most efficient modern rapid transit systems.

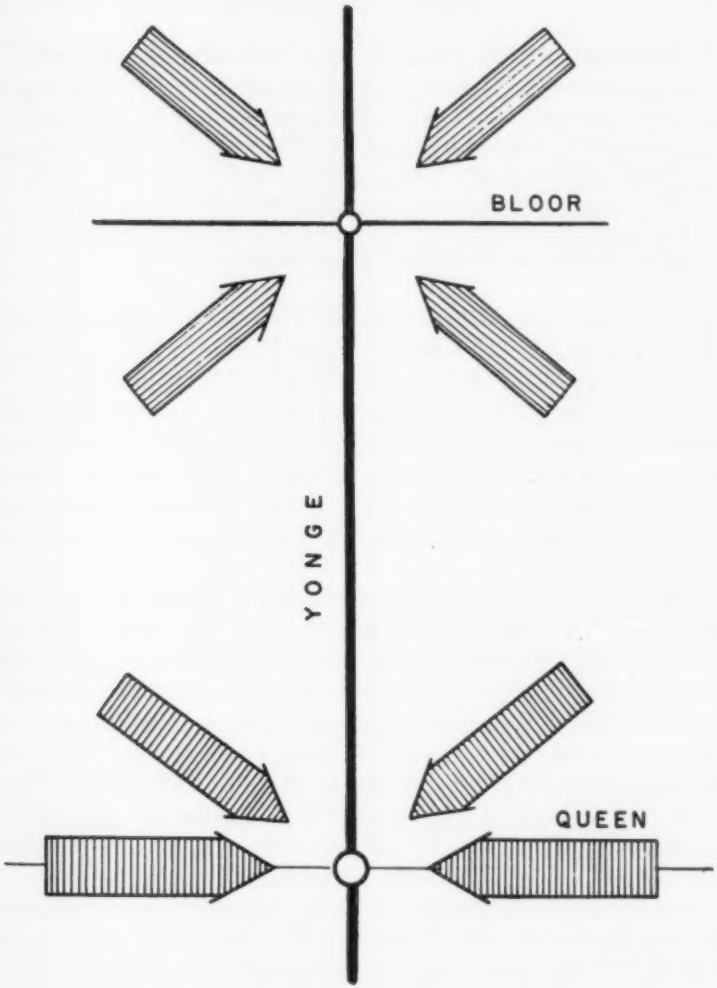



Figure 16.

# Human Factors in Highway Safety

RICHARD M. MICHAELS

*Dr. Michaels, Ph.D. in Psychology, George Washington University, served for six years as Engineering Psychologist at the Naval Research Laboratory where he conducted research on human vision and audition relevant to antisubmarine warfare and sonar detection systems. He is head of the Human Factors Project in the Division of Traffic Operations of the Bureau of Public Roads. The group is involved in psychological research on driving behavior and highway safety. Dr. Michaels is a member, American Psychological Association; and of the American Association for the Advancement of Science.*

TO discuss human factors rationally it is necessary to define the area in which they operate. A preliminary step should specify what highway safety means and the limits of the field.

Historically, the basic concern of safety has been to define the causes and effects of traffic accidents. Such a frame of reference, however, has scientific meaning or practical use only if *accident-causality* can be defined operationally. This is fundamental for any effort in safety and, incidentally, determines those human factors most relevant.

There are basically two ways in which accident-causality may be defined. The first approach may be called the *specific defect* approach. This view holds that failures or defects in the components of the highway system are the direct cause of the highway accident; e.g. brake failure, pavement failure, etc. This approach leads to an intensive analysis of accidents to deduce the causal defects. By the intensive study of enough accidents it should be possible, according to this view, to specify what these defects are and help to eliminate them. This view of highway safety has actually been the predominant frame of reference in the field.

A more refined statement of this approach is that any accident has multiple causes. One factor may contribute little; the sum of all determine the occurrence. Stated in the form of an equation:

$$X=a_1f_1+a_2f_2+\ldots.+a_nf_n=\Sigma a_if_i \qquad (1)$$

In this case all the factors are independent of each other.

The so-called accident factors, however, are usually random

variables and interdependent. These assumptions lead to the general statement of accident occurrence as a multiple regression equation of the form:

$$X=a+{}^{b}1.2,3,\ldots,k{}^{x}1+{}^{b}2.1,3,\ldots,k{}^{x}2+\ldots+{}^{b}k.1,2,\ldots,k-1{}^{x}k \quad (2)$$

Where the "b" coefficients are the partial regression coefficients.

This, then, is the general statement of a linear factor theory of accidents. The problem has been to determine the variables—man, machine, highway—that optimize the solution of this equation. Optimization here means that solution which comes closest to predicting the most accidents. More generally, it means that the maximum amount of variance in accidents is accounted for by the sum of the terms in the regression equation.

In the effort expended upon this approach, few solutions involving specific system variables have accounted for any large portion of the total variance of accidents. All things considered, roughly twenty-five percent of all accidents can be accounted for by fixed characteristics of vehicles, highways, or drivers.

The paradox of the multiple factor theory is most clearly evident in the study of highway factors as they relate to accidents. Most studies of highways indicate that in only about five percent of the accidents do observable characteristics of the highway play a significant causal role.[1] Yet studies do indicate that modern controlled access highways yield accident rates only one-third to one-half of the lower type facilities running parallel to them.[2]

## MULTIPLE-FACTOR APPROACH

Many possible reasons have made the multiple-factor approach unproductive. They vary from the statistical characteristics of the factors to their time-varying nature. A more fundamental possibility, however, is that a linear-factor theory of accidents is inherently incomplete. Basically, the factor theory assumes that within the framework of the system are singular elements whose interaction causes accidents. If, however, accidents arise as a consequence of random errors in the operation of the system, then any prediction using a linear factor theory would be negligible.

1. Raff, M. S., "The Interstate Highway Accident Study," *Public Roads*, June 27, 1953.
2. The Federal Role in Highway Safety, U. S. Government Printing Office, Washington, D. C., 1959, 57–59.

If accidents do, for the large part, arise from purely chance-factors, it should be possible to predict the percentage of drivers having a given number of accidents. That is, if accidents are rare in time and space, they should be distributed according to a Poisson distribution (Figure 1). This assumes that all accidents occur strictly by chance with no predeterminate causes.

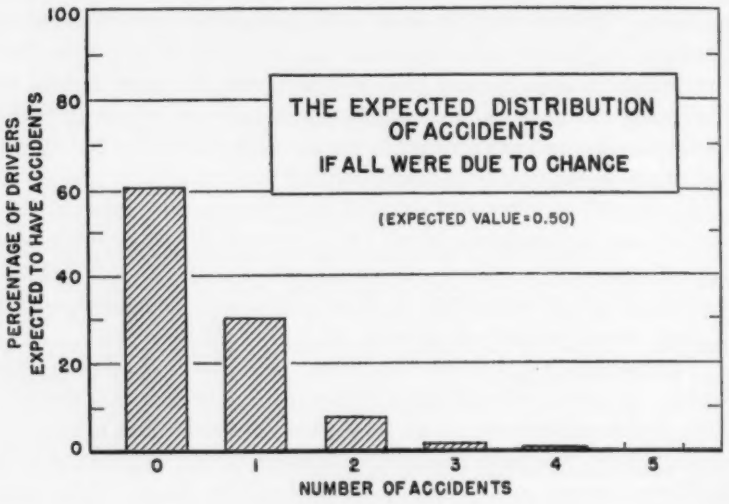



Figure 1.

This implies, furthermore, that highway accidents as collision events are no different in kind from, say, collisions among gas molecules. Two studies of accidents bear on this assumption. One is a study of aircraft accidents by Thorndike[3] and the other by Cleveland[4] on automobile accidents. These studies indicate two things. First, the Poisson is not a perfect description of the accident distribution. There are more drivers who have no accidents than is to be expected if accidents happen by chance alone. Second, there seems to be a stable but small group of drivers who have more than their share of accidents and these are called accident repeaters.

3. Thorndike, R. C., Human Factors in Accidents, with Special Reference to Aircraft Accidents, U.S.A.F. School of Aviation Medicine, project 21-30-001, Randolph Field, Texas, 1951.

4. Cleveland, D. E., Driver Characteristics and Speed Performance Related to the Facility, Highway Research Board Bulletin No. 212, 1959, 1–10.

Actually, Cleveland's Virginia data indicate that nine percent of the drivers contribute forty-eight percent of all the accidents whereas by chance alone it would be expected that nine percent of the drivers would contribute forty percent of all the accidents. In general, the studies done in this area indicate that accidents are mixed events, composed of a small proportion of stable characteristics of the elements of the system, such as roadway curvature, a small proportion of time variable characteristics such as transitory emotional states in the driver, and a large proportion of random error. A reasonable estimate of the division indicates that somewhere between sixty and eighty percent of all traffic accidents may be due to random errors.

From this discussion, it appears reasonable to conclude that a large proportion of accidents have no cause. That is, they are truly accidents in the strict dictionary definition: an event not specifically caused or predictable.

In terms of the present conclusion, each accident, then, is a world of its own that may be described in detail. Its causes, however, are specific only to this particular accident. Such a result does not mean that highway safety cannot be achieved. Rather, it implies that the problem must be redefined.

In its broadest sense, what is a traffic accident? Essentially, it is some kind of error in the over-all functioning of the system. It is no different in kind from the unavoidable small wanderings occurring in a car's traveling a tangent section of highway. As a matter of fact, any deviation from an ideal path represents error in system-operation and differs from an accident only in degree: The accident requires a collision of some sort. The real distinction between the accident and any other driving error is that it is usually terminal and destructive.

## "SYSTEM" AND "ERROR" DEFINED

In this description, two terms need definition. The first of these is the concept of *system*. In its most general definition, a system is an assembly of elements that carries out operations by the interdependent operation of the component parts. The highway transport system is a singular one in that man, the driver, is one of the component parts. We have, therefore, a man-machine system. The significance of this will become apparent later.

The second term *error* also needs clarification. The output of an ideal system may be defined:

$$O=f(I) \tag{3}$$

where I is the input
and f a system transfer function

Whenever a system generates an output response that deviates from this predicted output, it is said to have made an error. These errors are of two kinds: constant and variable. The constant error is a fixed or invariant deviation of the output from predicted. It is a *specific defect*, for which compensation can almost always be made. Thus, a production "bug" represents a constant design error which is ordinarily corrected in manufacture when once discovered.

Variable or random errors are a different order. A steering linkage with excessive play would show itself by high variability over time in the lateral location of the vehicle on the roadway. In this case, the individual parts of the steering system are not faulty, rather it is their interconnections. Thus, there is nothing wrong with the elements themselves. Yet the output is only nominally predictable from a given input. It is this random variability that constitutes the general problem in the functioning of most systems, and the magnitude of this variation is actually a measure of the reliability of the system. In general, then, the system function may be defined:

$$O=f(I(1+C+V)) \tag{4}$$

where C is a constant
and V is a random variable
and f some system transfer function

Now if a system is composed of k components each having a variable error, $^{s}k$, then the total error of the whole system is defined as

$$^{s}T=\sqrt{^{s}1^{2}+^{s}2^{2}+\ldots{}^{s}w^{2}}=(\Sigma^{s}i^{2})^{1/2} \tag{5}$$

This assumes that the component errors are independent. If they are not, a term must be added to take into account any correlation. It should be obvious that the above equation is a measure of the reliability with which a system operates. If the component variances are zero, then for any input, the output of the system is completely known or predictable.

As the component errors increase, then two things must happen.

First, knowledge of the input is of decreasing value as a predictor of the output of the system. Second, the range of output for any given input becomes increasingly wide. From these two facts it is possible to see how accidents arise as random occurrences in the highway transport system.

For a given total variation, a certain proportion of the responses in the driving system will yield an error great enough to cause a collision. For a given variance in lateral location, for example, a driver will at some time wander from his lane. If the movement carries him onto a shoulder, it is called a run-off-the-road accident.

From this discussion it may be concluded that the safety of the system is really to be defined in terms of the classes of variable error and their magnitudes that occur in its operation. A safe system is therefore one in which the variable errors have been minimized. More generally, the objective of highway safety is to increase the reliability of the driving system. Achievement of this objective must coincidently, reduce the probability of what the layman calls *accidents*, for these low probability events would be decreased even further.

The objective stated above very clearly requires that the first and fundamental objective of highway safety must be to develop an understanding of how the driving system functions. Ultimately it is that knowledge that will allow modification of the system to achieve minimum-error operation. This approach implies, paradoxically, that the achievement of highway safety will be attained through the study of driving and not through the study of accidents.

It is now reasonable to state a general perspective under which human factors in highway safety may be viewed. All drivers have certain capacities that are required by the driving task. The very nature of the task makes universal demands upon drivers. If these are at the very limits of man's capacities, extreme responses are bound to occur.

### EXAMINING DRIVER-BEHAVIOR

Ultimately, therefore, it is the ways in which the demands of the task are adapted to the characteristics of the human being that will determine the safety or reliability of the highway transport system. It is very artificial to conceive of human factors as a set of

unique traits distinct and independent from the system in which they must operate.

Within the framework of the driving task and the demands it makes upon the individual driver, it is possible to examine the processes and functions that driving behavior requires. The problem may be cast in the form of the following question; what kind of operations does driving require of the man and how well do the human capabilities satisfy these requirements? These two questions are obviously two sides of the same coin, and they define, incidentally, what is known in modern engineering psychology as the systems analysis approach.

It is reasonable to examine the functional properties of the human being especially in terms of the task demands. Figure 2 is a grossly oversimplified representation of the behaving organism. By following through this diagram it may be possible to develop some feeling for the tremendous complexity of human behavior required by the driving task.

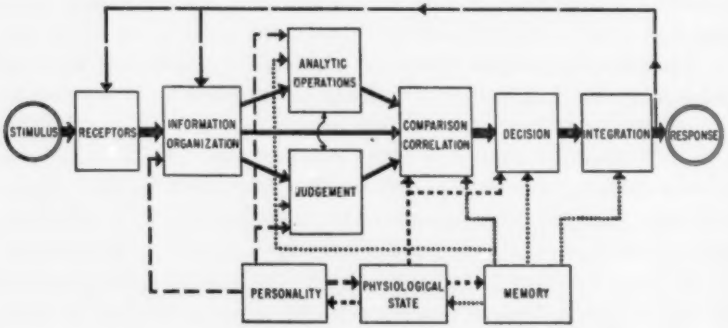



Figure 2. A Simplifed Representation of Human Information Processing.

Information from the environment is received by the senses which respond in an elemental yet selective fashion. The eye is not a camera mirroring the stimulus, but rather it is a selective receiver operating on information in different ways in both time and space.

The output of these receptors then undergoes a process of further

selection and organization that is generally called perception, to distinguish it from the primitive selectivity of the senses. Perception may be termed the first transformation of environmental stimulation into meaningful human information. Its determinants are complex, depending in part on what has immediately preceded, on expectations, and immediate as well as long-term needs. Perception depends first on the nature of the information coming in but secondarily and very importantly upon the individual's emotional state and the enduring characteristics of his personality.

Thus, viewing the output side of this box, perception may be called the first representation of the real world. Obviously, the more closely that perception describes the environment as it really is, the more accurate will be the outcome of the subsequent operations performed on the perception.

Driving requires the human to guide his vehicle. This means he must operate upon his perception. For example, if a curve is perceived while driving it is necessary to operate upon that perception to determine the corrective action that must be taken to stay on the road. Thus, some kind of analysis must be performed in order to determine the kinds of responses required. In the present example, the human is required to estimate the degree of curvature in the road, the speed with which the curve can be negotiated, and the change in speed that will be required—to mention just a few.

In essence, driving requires man to function as a guidance system which in many ways is functionally identical to that in a rocket. It is obvious, therefore, that the accuracy with which man can solve the guidance equations will, in part, determine how reliable the system functions. It is well known that the human does rather poorly at solving most of the differential equations required in guidance. He is especially inefficient at solving problems involving acceleration or higher derivatives. Furthermore, the solutions become even worse when either the magnitudes of the required solutions are large or the time allowed for solutions is made small. The fact is that man can solve these guidance equations accurately only over a very narrow range of conditions.

Therefore, sharp, or frequent curves, fast changes in speed, or rapid changes in locations require solutions man is ill equipped to make. There is little doubt that driving often imposes upon the

driver demands such as these which are at or near the limits of his capacities. Consequently, the highway system must function unreliably under these conditions.

### LEARNING PLAYS A CRUCIAL ROLE

As part of the analysis process more information is required than may be directly available from the environment. The driver must make judgments of various kinds to carry out the analysis. In a sense, the driver must supply a set of constants to solve the equations facing him. In addition, he must compare and correlate the current information with his past experiences. Much of decision-making is determined by the consistency of solutions with experience.

Thus, *learning* plays a crucial role in the efficiency with which the driver carries out the task of driving. For it is out of this learning that develops the set of expectations, correlations, and judgments, upon which sound driving decisions are made. It is obvious that the broader the learning the better able will the driver be to cope with the complex problems of driving.

It is equally obvious that the fewer the variety of experiences that the system requires, the more efficient can be the learning. Here, however, the transportation system fails the human. On two counts driving places excessive demands on the driver.

First, the tremendous variety of driving situations far exceeds man's capacity to retain and utilize information. Second, the kinds of experiences required are usually not the type that make for optimum learning or utilization. Therefore, the system insures that man's capacity for information assimilation is overloaded. Consequently, this means many errors in processing and increased learning time.

Results of this complex process of analysis lead ultimately to some set of decisions. Since the analysis is not perfect, the solutions involved in driving are not precise. In every human action in relation to driving there is some degree of error. One common problem for the driver is to decide which of the possible solutions contains the least error. Thus, there is a range of risk involved in any driving response.

What particular decisions are made will, therefore, depend upon the solutions available, and the level of risk that is acceptable.

It is interesting to note how much has been expended in trying to influence drivers to reduce their level of risk acceptance. Defensive driving, *Slow Down and Live* type slogans are two examples.

This approach would appear to be of rather limited use, for if people really knew how great the risk was in such driving situations, most would not ordinarily accept it. This implies that drivers often have no way to really predict the risk they are taking. It would be better to concentrate on decreasing the uncertainty of solution, for that automatically would reduce risk taking.

### TWO-STEP PROCESS

After making a decision and selecting a course of action, the driver is then required to translate this solution into a physical response. This involves a two-step process. First, the human must translate the results of his analysis into a set of "instructions" for instituting a change in his control operation.

Second, he must act physically on the vehicle and make his response conform to the instructions. He must turn the wheel in an amount equal to his chosen solution which estimated the radius of curvature. He must apply deceleration consistent with his chosen solution of the speed at which the curve can be taken.

The problem, again, is how well can man carry out these integrations? From other areas of research it is evident that there is considerable error in many of the integrations that man carries out. Many tracking studies indicate that accuracy depends on certain basic characteristics of the man and the construction of the system. The human can follow targets whose positions change regularly in time.

Whenever there is a change in speed of the target, however, man has an increasingly difficult time, and his errors increase. Furthermore, with a high frequency or large magnitude of change human performance begins to break down and errors increase tremendously. Many driving situations such as turning and passing often require such control responses from the driver.

The system variables that determine performance in control operations are complex. When a foot pedal is used as a control device, for example, the efficiency of operation depends upon its location, shape, resistance to displacement, and the relation of the

action of the control pedal to the response of the machine. This last variable may be very important in driving. For how does a driver know how much pressure to exert on the accelerator to obtain a given amount of acceleration?

The consequences of all control actions are invariably made known to the driver: He has feedback. This feedback occurs in several ways, but there are two main ones. The obvious one is his perception of change in location or speed. Thus, from the environment the driver gets the information which tells him what he has done and how well it corresponds to what was planned or expected. From this he can correct for errors in the whole guidance and control process.

Thus, feedback is a very important, if not a dominant, means that the driver has for compensating for his inherent inaccuracies. It is also evident that restriction or elimination of feedback must lead to higher magnitude and more frequent errors. Thus, it is possible to understand why such factors as fog and darkness may increase the difficulty of driving.

A second way the driver gets feedback is through his control responses. He knows when he moves the wheel or presses the brake pedal. He estimates how hard or how fast he carries out these operations. By comparing muscular responses with the information from the environment he can tell whether he has used the proper amount of control effort. The more perfectly he can correlate these two sources of information the better he can ultimately learn to control his vehicle.

### TREMENDOUS VARIETY AND COMPLEXITY

From this discussion of human factors it is possible to see the tremendous variety and complexity of behavior that driving requires of man. It is also obvious that the driving system will frequently place excessive demands on the human being. This means that the driver is often working fairly close to the limits of his analyzing and responding ability.

Thus a certain proportion of the time the transportation system is running marginally. In such a marginal system it is difficult to predict what will happen under any given set of circumstances, for it exhibits such great differences among different drivers and

within the same driver at different times. Finally, such a system is subject to a high variable error. In the extreme case these errors are what are called "accidents."

It is reasonable at this point to show how changes can improve the reliability of this man-machine system. Earlier there was mentioned the paradox that specific highway features appear to account for only around five percent of all accidents, yet the modern controlled access highway reduces the accident rate fifty to seventy percent. This paradox can be resolved by examining certain design standards of the Interstate Highway System in the light of this system analysis discussion.

The basic feature of these roads is that they permit no entry or exit except at specific, well-marked points. Furthermore, such access always joins the main roadway at small angles. By this procedure it is possible to eliminate the great changes in speed required to negotiate a turn onto a street that enters at right angles. Thus, the exiting driver is relieved of the complex task of estimating large decelerations and distances as well as large turning angles.

In addition, the exiting driver needs to be less concerned with following vehicles for he leaves the main roadway without introducing a speed change relative to the following vehicle. The following driver avoids the problem of predicting and compensating for these large changes in speed compounded by the variability in response of the turning driver.

Finally, elimination of cross traffic precludes the need for analyzing the activity of drivers approaching on the most unpredictable of collision courses. On the "on" ramp an acceleration lane is provided so that the merging driver can approach the speeds of traffic on the through lanes before entering. Thus, his problem of merging is simplified to the extent that the judgments of speed of through vehicles are over a smaller range of differences.

Ideally, merging at an on-ramp becomes weaving that is a simpler problem for the driver to solve. It may be seen that control of access generally reduces the range of analysis that is required and also reduces the magnitude of control changes that are required. Access control thus demands far less from the driver, allows him to operate over a more efficient range of his capabilities, and reduces the complexity and uncertainty of his decisions.

A second design standard of expressways is that the curvature of the roadway generally does not exceed 3.5 degrees. Such a standard greatly reduces the need for drivers to be able to make accurate estimates of curvature and to be able to make accurate analysis of the interaction of curvature and speed changes. Again, the demands upon the driver are reduced to a point where they lie within his more reliable range of operation.

A third standard limits the grade on the interstate system so that we rarely find grades exceeding three percent. Such a standard minimizes the effects of hills on passenger car performance, thereby eliminating many acceleration uncertainties for the driver. This is even more obvious with truck performance and their interactions with passenger cars.

Finally, a three percent grade will also prevent crucial restriction in the distance at which the driver may see ahead, thus allowing him to obtain and maintain consistent and complete information about the environment. This again improves his feedback and makes his decisions more accurate.

It may be seen, then, that the interstate type of highway reduces the complexity of the equations man must solve, and increases the availability of information he needs. At the same time, it reduces many extraneous sources that overburden man's limited capacities as a guidance and control system. In essence, these highways are designed to increase the reliability of the driving system and increase its tolerance of error. Within the definition of highway safety described earlier, a small increase in system reliability must yield a large reduction in accidents.

This, then, is the resolution of the paradox. Whereas individual highway elements themselves affect accidents only slightly, modern highway design increases the reliability of overall system functioning. In addition, modern highway design is essentially an attempt to better match the system to the capacities of the human. And, ultimately it is the degree to which this matching succeeds which determines whether traffic operations are improved, travel economies are obtained, and whether accidents are reduced.

This example of engineering advance is only one of several that may be described in both the highway and vehicle fields. Ironically, much of this progress has occurred without a profound understanding of the human factors.

This leads to a last point. What has been described as the systems analysis approach is a tool through which can be developed a basic understanding of the human role in the driving task. From this understanding can come the criteria for the design and engineering of a reliable system—one that is safe.

# Function of the Insurance Institute For Highway Safety

RUSSELL I. BROWN

*Mr. Brown is President of the Insurance Institute for Highway Safety with headquarters in Washington, D.C. Prior to this appointment he was Commissioner of Public Safety of Iowa, the first non-political appointee to the office. While he was commissioner, Iowa experienced its largest reduction in traffic deaths, except for the wartime years of curtailed use of motor vehicles. Mr. Brown is a member of the Board of Directors of the National Safety Council Advisory Committee, Center for Safety Education, New York University; Advisory Committee, President's Committee for Traffic Safety; Institute of Traffic Engineers, and consultant to the Public Health Service, Department of Health, Education and Welfare.*

THE Insurance Institute for Highway Safety is one of those interesting phenomena that occur when great ideas become a reality. It also is in the American tradition of men caring enough to protect the lives and property of others.

IIHS was created in January, 1959 by three major casualty insurance associations—the Association of Casualty and Surety Companies, the National Association of Automotive Mutual Insurance Companies, and the National Association of Independent Insurers. These groups represent more than 500 companies which write about eighty percent of the nation's automobile insurance.

The automobile insurance executives who brought the IIHS into being looked beyond their competitive endeavors. They realized their industry had a tremendous stake in highway safety work —not only from the dollar standpoint, but equally, if not more important, from the humanitarian point of view.

They realized that the best approach to a stepped-up attack on the traffic-accident problem should be made through a *joint* effort.

Through the Institute, the industry hopes to strengthen the work of highway safety organizations it helps to support, and to eliminate duplication of effort.

For many years prior to the formation of this organization, insurance groups, individual companies, and key individuals

contributed substantially in time and money to highway safety programs. Were this not so, the problem today might be much worse. What had been lacking among insurance groups through the years was a focal point for these efforts. To this end, the IIHS was formed.

The Insurance Institute has only one objective: to reduce highway accidents. We seek to accomplish this objective through two major fields of activities:

1. Direct assistance for official traffic safety programs in selected states;

2. Financial support to organizations doing effective work that contributes to highway safety.

We believe these fields complement each other effectively. The organizations that receive financial support from us are the best equipped and best qualified to help the officials in our "direct assistance" states.

## DIRECT ASSISTANCE

There is general agreement that, to reduce traffic accidents, a state should have a complete, balanced program. Further, there is general agreement that the action program of the President's Committee for Traffic Safety is such a balanced program. It is a standard for highway safety programs to follow.

The action program calls for improved and intensified effort in the areas of accident records, education, enforcement, engineering, laws and ordinances, motor vehicle administration, organized public support, public information, and research.

The purpose of IIHS direct assistance is to help the officials of selected states implement fully a balanced program—the *action program*. The Institute provides a unique service to highway safety. We serve as a stimulating, planning, fact-finding, energizing, and coordinating agency.

It is implicit in our assistance program that what we do, we do on a pump-priming basis to stimulate officials and citizens of those states to assume their own responsibilities.

We endeavor to get the states to pay for those technical services they will require from other traffic agencies. We endeavor to get the citizens of the states to carry on and pay for the public education

programs. In our work with officials and citizens, we urge them to assume full responsibility for their traffic safety programs so that outside assistance will be required only temporarily. In short, we try to work ourselves out of a job in each of the states in which we provide this help.

### ATTACKING ACCIDENTS IN FOUR STATES

In January, 1960, the Insurance Institute for Highway Safety was invited by the officials of several states to examine their traffic safety programs to determine whether IIHS assistance should be provided. After months of intensive preliminary investigation by our staff, the Institute's Board of Governors approved the offering of direct assistance to Arizona, Florida, and Wisconsin. We went to work in May, 1960.

In the states in which we are working, the program is the program of that state, of its officials and its citizens, *not* the program of IIHS. The *doing* and the *leading* are by the state's people, not by IIHS. The state develops the program and provides the leadership for it.

In general, we apply the resources necessary to facilitate the achievement of the state's program. We work for a state as long as a sound and balanced program is foreseen. When such a balanced program is a reality, we plan to offer our services elsewhere.

Direct assistance in New York was adopted by IIHS as a continuation of some of the work begun in 1953 by the state's insurance interests as a pilot program.

### DIRECT ASSISTANCE TO ARIZONA

The State of Arizona already had much of the legislation needed for a sound program of traffic accident prevention when IIHS services were requested in 1960. It was apparent that many improvements could be made administratively. The role of IIHS in this state, primarily, is to provide staff counsel to Arizona officials in the implementation of *their* program. Progress has been good.

State officials are establishing a central records bureau properly staffed and equipped to process and analyze accident reports and to provide regular summaries and special studies. IIHS staff members have aided in this work and also have helped revamp the

records systems of several municipal police departments in the state.

A substantial improvement in the state's point system was effected in the spring of 1961 when the highway commission reduced the number of points from twelve to eight at which a driver is called in for a hearing. The Arizona Traffic Safety Foundation and the state will conduct a public information program to acquaint drivers with this change.

A justice of the peace manual is being prepared and a model traffic ordinance is being drafted.

IIHS considers a strong state-wide public support organization essential to the success of an over-all traffic safety program. That is why we have pledged up to $10,000 in 1961 toward the support of the Arizona Traffic Safety Foundation. IIHS funds will supplement those provided by the state's business and industry.

Governor Paul Fannin has requested IIHS assistance in updating a 1953 study of the Highway Commission (including the Highway Patrol and Motor Vehicle Department) and the Courts of Limited Jurisdiction of Arizona. The study was made by the Traffic Institute of Northwestern University, American Bar Association, and American Association of Motor Vehicle Administrators. It is anticipated that these three agencies will participate in the modernization of the 1953 recommendations.

Governor Fannin is strong for highway safety. Last December he went "back to school" for three days with his top state officials to study traffic safety management. It is believed that this was the first time that such "high level" students have attended a traffic safety course. The New York University Center for Safety Education conducted the training with funds provided by the IIHS.

### DIRECT ASSISTANCE TO FLORIDA

In our opinion, Florida's traffic safety program also is progressing satisfactorily. Important highway safety measures were passed by the legislature in the spring session.

Issuance of driver-licenses was placed on a birth-month and biennial basis. The legislature authorized an increase in the Florida highway patrol from 500 to 600 men. High school driver-education got a boost when twenty-five cents a year was added to the driver-license fee for extending driver education to all high school students.

The proposals were developed and supported by the Florida citizens advisory committee on highway safety. IIHS staff provided technical consultation as requested by the legislative council and the citizens advisory committee, and in addition furnished public information services.

A study of Florida traffic courts is being made by the American Bar Association. Begun in late winter 1961, this will take two years to complete.

Another study—that of the department of public safety by the International Association of Chiefs of Police, assisted by the Traffic Institute of Northwestern University—has been completed and is being reviewed by the Florida department officials.

IIHS assisted in financing these studies. Both are expected to have far-reaching effects on the state's traffic safety program. IIHS also bears a portion of the costs for such activities as in-service training of state personnel and public education and support. IIHS funds are used in this way to energize expenditure by private organizations and public agencies.

IIHS also provides public information assistance to Florida. We are helping the department of public safety acquaint Florida drivers with the new legislation on birth-month and biennial issuance of licenses.

Early in 1961 we produced a thirty-minute film covering the state's major highway safety needs. Copies of this film were distributed to all Florida television stations and were shown to citizen groups. The film was issued in the name of the citizens advisory committee.

IIHS also provided the citizens advisory committee with a fifteen-minute radio panel discussion on Florida's highway safety needs. Recordings were sent to 150 radio stations.

IIHS is constantly seeking ways and means to strengthen the advisory committee to give Florida an active state-wide public support group. The National Safety Council also is assisting in this project.

Governor Farris Bryant of Florida, like Governor Fannin of Arizona, is not only a firm believer in highway safety but also an ardent supporter.

In a statement several months ago in a special highway safety

edition of *Florida's Business*, Governor Bryant acknowledged the IIHS role in his state's safety program. He said:

"We are benefiting from the assistance of the Insurance Institute for Highway Safety which has made many special studies for us, currently is making additional studies and has agreed to do even more in the future. Without its technical assistance, much of our work would not be in the advanced stage it has reached."

### DIRECT ASSISTANCE TO NEW YORK

When IIHS was established in January, 1959, the traffic safety work of its three member associations was transferred to the new organization.

As one of the associations had been helping to organize the New York State Citizens Council on Traffic Safety, IIHS continued to provide assistance. The council is now pursuing a vigorous public support program in the state.

The IIHS staff has been serving on a committee studying the uses of traffic accident records at all levels of state and local government. This study, completed in the spring of 1961, is being considered by Governor Nelson Rockefeller and his staff. It is anticipated that IIHS will be asked to assist in the implementation of the recommendations, if they are accepted.

### DIRECT ASSISTANCE TO WISCONSIN

In Wisconsin, direct assistance is concerned primarily with strengthening the state-wide citizen support organization.

The Wisconsin Council of Safety has for many years operated successfully in the industrial safety field. When it decided to expand its influence to highway safety, the IIHS was asked to provide temporary financial assistance to stimulate increased contributions from business and industry.

The council added a staff man who is assigned full time to traffic, and the council has prepared a set of objectives toward which it will work. During the 1961 session of the legislature, the council supported standard accident reporting, extension of state financial support to high school driver education, and additional license examiners to strengthen the state's driver improvement program.

IIHS staff assisted the council in setting up traffic safety clinics in twenty key Wisconsin cities early in 1961. More than 1,000 leading citizens attended these sessions. The clinics were actually conducted by the local people. IIHS and Wisconsin council help consisted of providing materials and offering suggestions.

A three-state traffic management course for officials of Iowa, Minnesota, and Wisconsin is planned for late 1961 in La Crosse, Wisconsin, under the supervision of the Center for Safety Education of New York University.

CSE/NYU receives financial support from IIHS, and the three-state course is an example of how IIHS financial support and direct assistance programs are dovetailed.

### GRANTS-IN-AID

The second of the two IIHS fields of activity—providing financial assistance to agencies doing effective work in traffic accident prevention—is a major effort in support of the action program of the President's Committee for Traffic Safety.

In a sense, the financial support program of IIHS can be considered "indirect assistance" to states and cities. This support enables key national organizations to provide essential traffic safety services throughout the country.

Recipients of more than three quarters of a million dollars in funds provided by IIHS in 1961 are: the President's Committee for Traffic Safety, Traffic Institute of Northwestern University, American Association of Motor Vehicle Administrators, International Association of Chiefs of Police, Traffic Court Program of the American Bar Association, the Center for Safety Education of New York University, the National Committee on Films for Safety, National Committee for Motor Fleet Supervisor Training, National Committee on Uniform Traffic Laws and Ordinances, National Safety Council, The National Teen-Age Safe Driving Road-e-o of the U. S. Junior Chamber of Commerce, and Yale University Bureau of Highway Traffic.

Not only do we provide financial support to these organizations, but, through advisory committees and periodic meetings, we seek constantly to help them upgrade their programs.

In addition to its two major fields of activity, the IIHS sponsors

two special projects—the highway safety promotional activities of the Association of State and Provincial Safety Co-ordinators and the annual national high school driver education award program.

### IIHS NATIONAL PROGRAMS

The co-ordinators group consists of elected or appointed officials who have a direct interest or responsibility for the co-ordination of traffic safety activities within their own jurisdictions. All fifty states, the District of Columbia, the Commonwealth of Puerto Rico, and the ten Canadian provinces are represented in the association.

The IIHS finances the activities of the association and provides the administrative staff. Principal activities of the co-ordinators are their special-emphasis programs: *Slow Down and Live*, an annual summer vacation program that emphasizes speed control; *Moral Responsibility in Traffic Accident Prevention*, *Child Safety*, and *Woman's Role in Traffic Accident Prevention*.

Also the association supports or participates in other safety programs such as *Operation Winter*, the Armed Forces-State-Federal Traffic Safety Workshop Program, *The National Vehicle Safety-Check for Communities*, and traffic management courses for state officials.

The sole objective of the annual national high school driver education award program is the expansion and upgrading of this important phase of traffic accident prevention. This program recognizes those states that have made outstanding progress and achievement in high school driver-education.

In the 1959-60 school year eight states received the achievement award for public high school driver-education. Two states and the District of Columbia received the progress award for public schools. Michigan, which was one of the recipients of the public school achievement award, also received a special award for providing driver-education in the public schools to private and parochial school students. Three states received the progress award for driver-education in private and parochial schools.

The governing body of the Insurance Institute is its board of governors, consisting of three representatives each from the three component associations. The general managers of the three associations are ex-officio members of the Board.

Safety leadership is a philosophy that weans the public away

from the inclination to dump responsibility for safety on public officials and safety organizations. I believe it must be a blunt philosophy which instructs the public that the highway safety movement will produce only as much of the desired product as money invested and equipment provided will allow. To be a success, highway safety must operate on a business rather than emotional level.

# Seeing Habits and Vision, A Neglected Area in Traffic Safety

REUEL A. SHERMAN

*Mr. Sherman, Manager of Occupational Vision Department, Titmus Optical Company, started his career selling stereoscopes and stereographs during college vacations for the Keystone View Company. Later in a full-time association with them he originated and promoted stereoscopic vision testing and training instruments and techniques that set the pattern for modern procedures. He joined Bausch & Lomb to initiate and direct development of the Ortho-Rater and their Occupational Vision Program. He coordinated the twelve-year research program on vision and occupations at Purdue University and other centers. In 1957, he initiated and directed the development of the Titmus Vision Tester. He is the author of articles and hand-books on vision and vision-testing as related to occupations. He and his associates, Harold L. Smith and John J. Cummings, developed the Smith-Cummings-Sherman method for teaching safer driving through correct seeing habits.*

IN this article, the important factors of visual acuity—the ability to read the 20/20 line of test symbols, discriminate between minor hues of colors or judge relative distances quickly and precisely—will be used for minor reference only while we deal with the effective *use* of acuity in vision or the *comprehension* of what we see for safe driving

The subject of vision has not had a fair break in the traffic field and probably will not come into its own until correct *seeing* habits get the attention they need and the *seeing* job—or the correct reading of the traffic scene—are understood, practiced and taught. Twenty/twenty vision in each eye, good depth perception, color vision, glare recovery, adequate visual fields and other factors can mean much to a driver who habitually practices good seeing habits. But they can mean much *less* to the driver who fails to use these abilities effectively.

A driver's habits of reading (or quickly comprehending) the traffic scene show up clearly in his timing of routine actions in traffic. He cannot hide these seeing habits from a trained observer because he is unaware of the resulting errors at the time he makes

them. Motorists do not, in their everyday driving, exhibit the superior seeing habits they are capable of building.

They have frequent near-misses and occasional accidents. Many traffic injuries and deaths occur among this majority of drivers, who frequently strive to escape from hazards an expert driver never encounters in normal driving.

Selective seeing habits are one of the largest factors in a driver's accident-expectancy rating. Sheer chance is the main factor in determining the *severity* of accidents when they occur.

The average driver does not do a good job of reading the traffic scene. Some of us have learned to read the printed page with speed, comprehension and skill but have not learned to apply the same skillful, effortless and effective seeing habits to our driving. In driving, each of us has learned and practiced his own methods. A few drivers—fewer than ten percent—have learned excellent traffic-reading habits.

Suppose school teachers taught our children to read by saying, "Keep your eyes on the middle of the page . . . be intelligent . . . read more carefully." This is analogous to the meager information given to drivers such as: "Keep your eyes on the road . . . drive carefully . . . drive safely."

Teachers of our children start with basic principles of reading and proceed step by step. The pattern of where the eyes should look, starting at the top of the page, reading from left to right, is learned and practiced by each pupil until fixed seeing *habits* are developed.

No longer need he concentrate on details. His mind is not tied to letters and words. By habit in rapid saccadic movements, the eyes pause momentarily here and there along each line at key words or phrases, which the mind must see to get full meaning—not at each letter or word.

Reading the *printed page* is analogous to reading the *traffic scene.* Our eyes can do a specific job efficiently for us when we train them properly in good habits of seeing. Without conscious effort, trained eyes follow correct patterns of seeing. They feed a flow of sensations to the brain which translate the important items into meaning and action.

Likewise, when our eyes are trained to read the traffic scene efficiently, the results will produce improved driving performance.

Fewer "reckless" drivers will appear "without warning." Fewer emergency stops are required. Even though our eyes are doing a more comprehensive and better job for us, we will drive with less tension and more pleasure.

Peter Spencer has stated, "Reading is that process of making discriminative reactions. There are no non-readers, but there are multitudes who read poorly and with too little facility certain things which our way of life holds in high regard."[1]

Even though driving is a highly specialized seeing job, our knowledge of the part played by visual perception in safe driving has been limited and incomplete. It has been neglected. As a result, misconceptions have, in some cases, become our commonly used guides. Until recently, the observable differences in drivers' seeing habits, which are distinguishing characteristics between safe and unsafe drivers, had not been recognized and used. They were not identified as a basic factor in safe driving.

Forbes,[2] Lauer,[3] and others have come close to but apparently stopped short of exploring and mapping this important area. Even the *pro*, who had driven over a million miles without accident, as he stepped to the platform to get his distinguished safe-driving award, was unaware of the functional factors that set his driving pattern apart from that of his fellows.

He might have responded by saying that he always drove carefully and soberly and obeyed the law, but he did not touch on, nor did he describe the key points of his superior performance—probably because he himself was unaware of what they were.

It is little wonder then that the researcher, who himself may be an above-average driver, did not pursue the "seeing" trail or stay on it long enough in his search for characteristics that differentiate safe from unsafe drivers. This may be a partial explanation of why so much emphasis seemingly has been placed on *symptoms* rather than *causes* of accidents. It may be a reason why basic factors such as the seeing habits of safe drivers have remained unexplored or neglected for these short 50 years since the automobile came into our quiet, provincial living and put millions of us on the highway.

In the opinion of those who have followed the trail of "how to see and what to look for in driving," the commonly accepted reasons for accidents can be symptoms which, when judged by appearances,

may be called recklessness, wrong attitude, inattention, carelessness, speeding, etc. In many cases, the real cause behind the "appearance" was not an anti-social point of view of the driver but only an unawareness on his part of important happenings leading him toward trouble. Accident proneness, for example, is a descriptive rather than an explanatory term. It does not identify causes. The basic cause behind drivers' actions in so many accidents is *failure to put good vision to use* through good seeing habits. Stated differently, the cause was failure to read the traffic scene.

Carmichael and Hugunin report,[4 5] "Learning to see and recognize traffic situations and conditions requires some formal training. Mere experience is not adequate.

"A great many accidents (more than previously supposed) can be attributed to driver inattention, which, in turn, leads to commission of unsafe acts."

Kephart reports on a recent Indiana study:[6] "It is interesting to note that in many cases of 'routine' type accidents, unsuspected perceptual errors were present. When the drivers were questioned as to what they perceived in the few seconds just preceding an accident, it is amazing how many were unaware of important factors such as other vehicles, obstructions, etc. The troopers themselves expressed surprise at how grossly unaware the drivers confessed themselves to have been. It is felt that these protocols offer important evidence of the significance of perceptual alertness in automobile driving."

The ratio of traffic fatalities to miles driven has been declining more rapidly than the ratio of accidents to miles driven.

The steady decline in fatalities in relation to miles driven probably is due to many factors. Some of these may be:

1. The surgeon's skill with improved medical technology and facilities has saved many lives that previously might have been fatalities.

2. Well-trained and more readily available Rescue Squads and others have played an important role in giving first aid and in getting accident victims to the doctor in a far more efficient way than was possible previously.

3. The automotive manufacturers have made consistent progress in building safety into cars—safety glass, removal of protru-

sions, providing seat belts, etc. Many an accident that now causes only property damage or injury could well have caused death if improvements in car design had not been made.

The steady decline in overall accidents in relation to miles driven may be due to many factors. Some of these may be:

1. Better engineering of roads and highways, with improved construction and placement of markers, guide lines, and signs, has made it easier for the average driver to reduce his driving errors.
2. Driver education is beginning to bear fruit.
3. Law enforcement practices and facilities have been improved greatly.
4. The impact of improved licensing procedures is beginning to get results.
5. Our children or grandchildren who are at the wheel today have the benefit of accumulated experience from three generations of drivers to guide them. They can be safer drivers than we are.

Through the efforts of many dedicated, intelligent people, progress is being made, but traffic accidents continue to plague us. A look at our safety education may suggest the degree to which we are trimming branches rather than digging out the roots of the problem.

### ERRORS CAUSE ACCIDENTS

"Bad" roads, inadequate signs, crowded highways, or low illumination do not cause accidents, but they make it easier for drivers to commit the errors that do cause them.

Driving errors—made by people—is the basic cause.

Favorite accident scapegoats—variously defined by many drivers—include the speeder, the reckless driver, the show-off, or the little old lady who gets in the way. Yet all drivers could well ask themselves, "Do I make driving errors myself?" The alertness of the other driver or a lucky circumstance may be all that saved us from serious results. The *number* and *type* of errors and the *frequency* with which they are made, plus the *awareness of errors being made by others* which might involve us largely determine the degree of safety with which we drive.

Most traffic accidents happen to sober, law-abiding citizens, who drive to or from their jobs, to church, to the club, to the home

of friends, children or parents, or take periodic vacation motor trips. These honest individuals are ministers, workmen, mothers, brothers and sisters, or sons and daughters, and law enforcement officers. From this cross section of our good citizens come the great majority of accidents.

The smaller number of accidents caused by willful disregard of regulations deserves special attention. When the majority of our good-citizen drivers learn to practice good seeing habits consistently our enforcement and court procedures can function with added effectiveness. The willful law breaker can then be isolated more easily and surely for special attention.

Safety records of millions of licensed drivers, when plotted, show a curve of distribution similar to curves on other human performances. A small percentage have never had an accident in many miles in all types of weather and over the poorest and the best types of roads. At the other extreme, another small percentage shows many accidents, on good roads in good weather. The *majority* of drivers have had one or two accidents ranging in severity from minor fender denting to fatalities.

Most of those who have studied driver-behavior have observed differences between accident-free and accident-experienced driver performance. From these observations Harold L. Smith and John J. Cummings first classified faulty habits of seeing and related them to commonly-made driving errors that often lead to near-misses and accidents.[7] [8]

Observable characteristics of the average individual who makes driving errors routinely are not related to willful law-breaking, destruction of life and property, drunkenness, attitudes of belligerency, or extreme selfishness. Rather they indicate that the poor driver does not read the traffic picture adequately. He periodically misses important clues of impending hazards. When he is worried or distracted, or for some other reason less alert, he may miss additional clues and experience more near-misses. He is not sufficiently aware of what other drivers are doing or are about to do that might involve him. The unsafe driver perceives even fewer important clues.

Conversely, the safe driver reads the traffic scene effortlessly, continuously, and comprehensively, even though he also may be unduly worried and even though he will or may engage in lively

conversation, enjoy the scenery to the fullest, plan his day's occupation or let his conscious mind wander to many subjects while he drives. His fixed habits of reading the traffic scene through trained eyes give him a distinct safety advantage over other drivers.

Many hundreds of road tests have been given by Harold L. Smith to classify drivers on their seeing performance while driving. The tests were administered and scores were given according to patterns developed by the Institute of Driver Behavior.[8] Figure 1

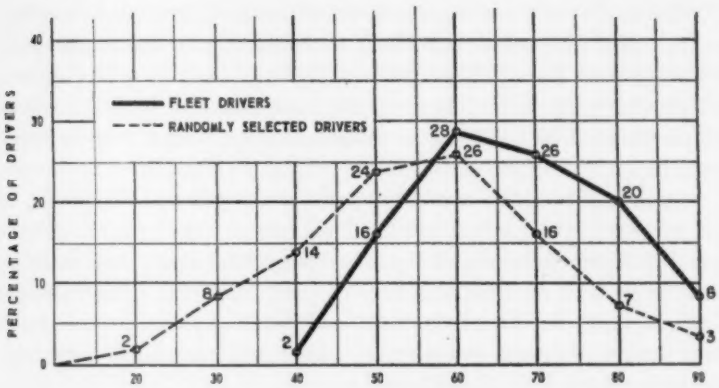



Figure 1. Road-test scores given by Harold L. Smith to 100 drivers from companies maintaining organized employment and safety programs compared to scores given 100 man-on-the-street drivers.

shows a comparison of road test scores earned by 100 licensed drivers selected at random and 100 drivers of commercial vehicles from companies maintaining training and safety programs. The better scores earned by the commercial drivers indicate that the least efficient ones have been separated from the commercial fleet operation by selection tests, unsatisfactory performance, or they have been improved through training.

## VISION AND SAFE DRIVING

*Seeing* is something we do. It is a mental act. It is a learned skill. It is not something which just happens to us. Some of us learn to see effortlessly, skillfully and comprehensively. Others, due to

poor seeing habits or deficiencies in vision, or both, see in a more limited, inefficient way.

Many studies have been made on the relationship between measurable functions of vision and safe driving. "Safe driving" was determined through available accident reports. The objectives of the research were: to determine which factors of vision were important to safe driving; to determine factually the vision standards for most efficient and safe driving; and the best means of measuring the visual factors which were found to be important.

On studies of random selections of licensed drivers, consistent but minor trends with only a very few statistically significant relationships were found. Those of us who have been involved closely with such studies have felt a certain frustration in repeated results which pointed in the general direction of our objectives without providing the "nailed down facts" which we sought.

Statistically significant relationships were found, however, in special groups such as bus and truck drivers or passenger car drivers from fleet operations where organized personnel hiring and training procedures and natural selection of personnel had been in effect for some time. For example, those who most obviously were inefficient or unsafe, even though they had excellent vision, were separated from the job. (See Figure 1.)

On studies involving driving records of licensed drivers—chosen only on a basis such as "reported" and "no reported" accidents—it was enlightening to find that individuals with so-called "best vision" were so often listed in the accident files. Evidently, they failed to use this good vision while they drove.

On occupations other than driving, research findings on vision and job performance have been fruitful. For example: Relationships between measurable factors of vision and employee performance on industrial and commercial jobs have been demonstrated repeatedly.[9] [10] [11] [12] [13]

Factually determined vision standards for many occupations have been established. Individuals who meet these standards are on the average safer, more effective employees. Those who fail to meet them, on the average, become safer and more efficient after they take steps to bring their vision up to standard.[13] [14] [15] As a result of this factual evidence, leading industrial and commercial

companies are using vision tests for employee classification and placement procedures as an integral part of their personnel programs. (See Figure 2.)

Results from research on vision and job performance in industry did not come easily. First it was necessary to establish the validity and reliability of tests and procedures. Often, better measures of employee success were required so that classification of employees into groups of relative performance could be more reliable.

Managements and employees of many leading industrial and commercial companies co-operated fully. The research, conducted in many areas, was centered at Purdue University.[15 16 18]

Close similarities exist between research problems encountered in the industrial-vision work done at research centers and studies on vision and traffic safety. Significant differences also exist. For example, on industrial jobs:

1. Workers were instructed specifically how to do the job, what to look for, and *how* to look before they started to operate.

2. Supervisors observed progress and the need for further instruction.

3. Checks on how well the employee did his job were available at any time through records of rejects, quantity of production or accidents which injure personnel, damage machines or spoil materials.

4. Industrial employees on their jobs may have intense critical seeing jobs to do, but seeing usually is confined to specific limited areas.

5. Only employees who did an acceptable job remained on it. Conversely, behind the wheel on the highway:

1. The *seeing* job in driving a car safely is not comparable to that of many industrial jobs. One may be no more difficult than the other, but the driver must read continuously the entire, constantly changing traffic scene.

2. Check tests to rate the driver on how well he performed at his seeing job were not available until recently.[8]

3. The only available criteria were recorded accidents or violations. Other measures and clues to poor driving performance were not considered at the time.

4. The seeing job of safe driving is not taught to the average

licensed driver. He learned to use his eyes as you or I learned.

5. Drivers were not eliminated from our highways through poor "job performance" as surely as were workers in industry and commerce. A sufficient number who had excellent vision but who *saw* poorly probably caused a loading of the data so that true facts might have been outweighed and masked.

6. Those with accident records usually were the ones considered *legally* responsible and not of necessity the ones who made the causal errors.

Furthermore, employees who were subjects for study on industrial and commercial jobs were hired by management specifically for the job *and were trained for it.* Also, they had demonstrated sufficiently good performance on the job to be kept on the payroll. Those who were not making the grade were given further instruction by their supervisors, or they quit because of their own lack of desire or ability to succeed, or they were separated through management action.

In contrast, the subjects for study on vision and traffic accidents had in large part no formal or authoritative instruction in how to see and what to look for. The seeing incompetents kept their licenses and continued to drive with nothing to help them but admonitions. Those who used their eyes skillfully to read the traffic picture learned on their own.

One of the biggest steps forward in industrial safety programs came during World War II when slogans and admonitions gave way to job instruction as a result of the War Manpower Commission's training within industry programs. Training employees to do their jobs had positive results in few accidents.

Jones states, "Job training is the keystone of more and better safety." Griffin states, "Good job instruction of all employees would do as much or more for safety than many of the conventional methods which we employ as Safety Men."[16 17 19 20]

A palatable way to teach the public how to see while driving can get results in the traffic safety field. Very usable factually-established vision-standards for drivers are those derived at the occupational research center at Purdue University from studies made on operations of mobile equipment, bus drivers, and other selected groups. While some drivers with excellent visual capabilities are in-

Figure. 2. Vision Tester in use. It contains 12 vision tests.

**Far Point (20 Ft.) Tests**

| Test No. | Target | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Both Eyes | T | R | R | L | T | B | L | R | L | B | R | B | T | R |
| 2 | Right | T | L | T | T | B | B | L | B | R | T | R | L | B | R |
| 3 | Left | L | R | L | B | R | T | T | B | R | T | B | R | T | L |
| | Snellen | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| | Equivalents | 200 | 100 | 70 | 50 | 40 | 35 | 30 | 25 | 22 | 20 | 18 | 17 | 15 | 13 |
| | Stereo | | B | L | B | T | T | | | | R | L | R | | |
| 4 | Depth | | 1 | 2 | 3 | 4 | 5 | | 6 | | 7 | 8 | 9 | | |
| | | A | | B | | C | | D | | | E | | | F | |
| 5 | Color * | 12 | | 5 | | 26 | | 6 | | | 16 | | | ○ | |
| 6 | Vertical | | | 1 | 2 | | 3 | 4 | 5 | | 6 | 7 | | | |
| 7 | Lateral | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | Demonstration | | | | | | | | | | | | | | |
| 8 | Slide | | | | | | | | | | | | | | |
| | Alternate | | | | | | | | | | | | | | |

**14" ☐ other**

| | Target | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | Both Eyes | R | L | T | R | B | R | T | L | T | L | B | R | B | L |
| 10 | Right | T | B | T | B | R | T | R | L | B | L | R | R | L | T |
| 11 | Left | B | L | B | R | T | L | T | B | R | R | L | R | T | L |
| 12 | Lateral | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | Alternate | | | | | | | | | | | | | | |

Figure 3. Statistically determined vision standard for Operators of Mobile Equipment. Scores earned on each of eleven tests are recorded by a circled number or letter. Shaded sections indicate undesirable areas.

efficient in seeing, others with uncorrectable vision deficiencies, of which they are aware, do a superb job of seeing within the limits of their capabilities. For example: the driver or industrial worker with usable vision in only one eye, when aware of the degree of his visual impairment, will compensate adequately and, through practice, learn to do a more thorough job of seeing than many individuals with normal binocular vision.

### THE EYE IS CAPABLE

The human seeing mechanism is adequate for the job of safe driving. Even though a technical and comprehensive description of the eye is somewhat out of place in this paper, an understanding of the two types of receptors in the retina and some of the highly specialized and specific functions of each will help to explain why certain patterns of using the eyes are so desirable.

As you look intently at a small object in front of you, such as a doorknob across the room, spread your arms from your sides and wiggle your fingers. You should be able to see the movement of your fingers without moving your eyes from the doorknob. You cannot see your fingers in sharp focus, but you should see the movement. A normal pair of eyes covers a visual field approximately 180 degrees wide and somewhat smaller vertically due to the limiting factors of our facial structure.

In all of this large, visually sensitive area of the retina, there is but one tiny spot, the Fovea centralis, in the approximate center where the cone receptors and the concentration of them permit us to see details in sharp clear focus. As you focus your central vision on a line of this type, you can see sharply only a few letters with each fixation of the eye. When looking at an object 100 feet away, an area only five feet in diameter can be seen in sharp focus with each fixation of the eyes. We shall refer to this small area of specialized, sharp-focus vision as *central vision* and to sensations coming to us through other areas of the retina as *indirect vision* or *peripheral vision.*

Some of the functions of peripheral vision are: to warn us of approaching danger from the sides, above and below, to keep us informed of movements about us without the necessity of directing our line of sight at each specific object, to keep us informed of our

correct spatial relation to objects about us, to detect those items about us to which we should direct our central vision for identification and interpretation, to guide our central vision in finding its way instantly and precisely to what our mind wants to see (without the constant flow of visual stimuli from indirect vision, the eyes would not be able to move rationally, and they could not guide or lead central vision to specific important objects), to enable us to see with very low levels of illumination. Its use is essential in reading the shadows and for spatial relations under low illumination—for nighttime driving as an example.[26] [27]

Functions of central vision are: to obtain sharp, clear visual images for identification and meaning of the objects viewed, to see color, to sense the *feel* of objects without using our tactile sense—smooth, rough, sharp, hot, cold, dry, wet, rigid, limber, rugged, fragile, or slippery. Often our visual sense needs to be reinforced through our tactile sense and conversely our tactile sense seeks confirmation through our visual sense. Stating it poetically, "we feel with our eyes."

This visual "feel" is important in safe driving. For example, we can "feel" the condition of the road ahead. Is it slippery? Eyes can detect conditions which require cautious investigation to confirm the facts. Peripheral vision can be termed *detection vision*, and central vision can be called *identification vision*.

The skillful, proper use of the eyes in driving puts both indirect and central fields of vision to effective use. For example, the *pro* keeps his eyes moving—he *never* lets them rest on any one item for more than a moment. He *never* keeps his direct vision nailed down to the road in front of his car and particularly so at night. Instead, he uses the lower part of his indirect vision for efficient steering. His direct vision then is free for more important work such as continuous scanning of the entire traffic scene, behind (through the mirror), to the left, to the right, to the instrument panel, to cars, to drivers, and to pedestrians who may be threatening his path, and to the road far ahead, that he may get clues as to what is happening or is about to happen that might involve him.

Only with central vision and a very small surrounding area of the retina can color be seen. Central vision identifies traffic lights. The *pro* spots them ahead of time and times his actions accordingly. When following behind a vehicle on crowded highways, while wait-

ing for an opportunity to pass safely, he leaves sufficient space between him and the vehicle ahead, first, because it is a well-established safety factor, but, more important, because it enables him to watch it with indirect vision while his central vision continues to do its job with the big traffic picture.

The good driver feels tense and uncomfortable when he is so close behind another vehicle that central vision is required to watch it constantly. In such situations, he cannot give desirable attention to surrounding factors.

### ALERTNESS, AND SEEING

Vision or seeing is a mental process. It takes place only when mental attention is directed to stimuli from images on the retina of an eye. When attention is withdrawn from such stimuli for any reason, seeing does not take place even though the retinal images persist. We see by a mental selection process. Without our awareness, our mind chooses to see or not to see objects from the continuous flood of optical images which cover the retina of each eye during every moment when our eyes are open and there is sufficient light for seeing. Our mind inhibits through habit visual stimuli in which it has learned or chooses to be disinterested. Our habits of choosing what we want to see determine in large part those visual images which are admitted to consciousness by the mind.

For example, if a driver's keen, absorbing interest is in an item such as a detail of a new model car, he may concentrate his central vision on the new cars he meets or passes while his mind inhibits other images which may be very important to his safe driving.

The *pro* may have the same interest in new cars but he does not look intently at them or at other cars on the road, except where potential hazards are in the making—and then only momentarily. They are but small items in the *big picture* to which he pays attention. He reads this picture through habit with his subconscious mind, continuously seeking factors which are important to him as a safe driver.

The more intently one fixes his central vision on any particular item, the less he is aware of sensations from his large 180-degree field of indirect vision. When sufficient concentration is given to central vision, the indirect, peripheral visual field can be temporarily inhibited and mentally inoperative. When this occurs the "*big*

*picture*" is lost. Travelling at sixty miles an hour, eighty-eight feet of blind driving would have occurred for every second of such concentration. Judgments of relative distances and speeds drop almost to the vanishing point when peripheral vision is halted. The *pro* moves his eyes through habits which keep both central and peripheral vision operative and effective at all times. Yes, he may miss seeing some driver acquaintance. He may not get the exact details of the grill construction of the new model car he met on the road. He may lose a few such details but, for those few he loses, he gains many more. His mind is free for other pleasurable pursuits, and he continues to read the traffic scene correctly at all times.

### WHAT PART DOES GOOD VISION PLAY?

The importance of good vision for safe driving probably will not be accepted and cannot be established fully until the importance of seeing is recognized. Every individual holding a valid driver's license can improve the quality of his driving by practicing the seeing habits of safe drivers. When sufficient consideration is given to this concept, it may well lead directly to the question:

"Do I have the type of central vision to permit me to do the seeing job most effectively, easily and comfortably? When my central vision is called on for immediate action, can it get a sharp clear picture instantly and accurately?"

In a substantial percentage of cases, central vision can be improved. Good central vision can be the least expensive and one of the most rewarding "*accessories*" to motoring that we can have. Of all measurable human functions, vision should stand at the top of the list. First, it can be measured so quickly and dependably. Second, it can be brought up to standard so quickly in such a high percentage of cases and at such a relatively small cost. Third, it is such an important factor in doing the seeing job well.

During investigations of vision and traffic accidents, many thousands of individuals voluntarily appeared for visual performance tests on precision intruments. Observations made from countless test records and comments from those tested, plus the consistent *trends* in favor of better vision can lead to certain general conclusions:

1. Better vision enables one to do the seeing job more easily and more efficiently.

2. Efficient vision should be comfortable. Some individuals see with unusual sharpness, but they experience discomfort or drowsiness from active uses of their eyes. On the surface, one can say that minor inequalities in seeing ability between the two eyes or other binocular functional irregularities may be a cause of this discomfort.

3. Many individuals are wearing glasses which were not intended for driving, particularly not for night driving. These glasses appear to be compromise prescriptions given to the individual as partial correction so that one pair of lenses could serve for all purposes. Such prescriptions can be inadequate and particularly so for night-time driving. For example, the myope (near-sighted person) may have requested one Rx only— a compromise between his needs in driving a car and his needs at his desk. This individual can be severely handicapped visually in seeing for safe driving.[24]

4. For those who drive during bright sunlight and plan to continue driving after dark, it is desirable to wear quality sun glasses— possibly with one's personal prescription ground into the lenses. As soon as the brilliant sunlight or glare begins to dim, the sunglasses should be removed. By following this practice, the eyes should adapt better to the limited illumination of after-dark driving. Under no circumstances should the sunglasses be worn during twilight or after dark.

5. Contrary to old concepts, most effective seeing for the driving job requires eyes which function instantly and accurately at instrument panel and windshield distances as well as at twenty feet and beyond.[25] If bifocals are worn customarily, they may well be worn while driving.

6. If your doctor can prescribe special glasses for the specific job of driving and if they will enable you to do your seeing more efficiently, the extra cost may be small indeed for the benefits they may bring.

7. Old concepts, such as "We need only enough central vision to see a cow in the road," were developed by those probably unaware of the comprehensiveness of the seeing job in safe driving. The seeing problem is not limited to reading the letters on a STOP sign at 200 feet, or other informational or regulatory signs: this is only a small but important part of the job.

The question often is asked if learning correct seeing habits will

take the pleasure out of driving. The answer is a positive *No*. Instead, correct habits make the job easier and more pleasant. We see more. Our subconscious mind takes over the job of detecting, seeing, analyzing, and adjusting speed to conditions, and leaves our conscious mind or other areas of our subconscious free to enjoy our driving or our conversation.

### DRIVING CAN BE MORE FUN

When we learn better seeing habits, we automatically take driving postures that permit our seeing more efficiently. As drivers practice and learn safe and correct seeing habits, they make posture changes by adjusting the height of the seat and by proper grasp of the wheel. Driving habits, whether they be in seating posture, placement of hands on the wheel, handling of the car in city traffic, or on the highway, indicate to the skilled observer the importance which the individual driver places on correct and adequate seeing and the degree to which he has learned and practiced correct seeing habits.

Some sources of information on specific steps in learning correct seeing habits are:

*Training Your Eyes for Expert Driving:* Harold L. Smith, John J. Cummings, Reuel A. Sherman. The Institute of Driver Behavior, 1380 Penobscot Bldg., Detroit 26, Michigan.

*Seeing Habits for Expert Driving:* Twenty-minute strip film—12-inch record and guide manual. Ford Motor Company, Traffic Safety and Highway Improvement Dept., Dearborn, Michigan.

"*The Eyes Have It*": Harold L. Smith, John J. Cummings, Reuel A. Sherman. Educational Affairs Department, Ford Motor Company, Dearborn, Michigan.

Drivers can be safe even when they are not alert, according to J. S. Baker, Northwestern University's Traffic Institute. "No driver can stay constantly alert." This truth is a restatement of why we should practice good seeing until the desirable patterns become fixed habits. When we reach this level our subconscious seeing will be alert and functioning automatically—ready to inform our conscious mind of the need for its instantaneous attention.

Furthermore, when drowsiness and fatigue begin to interfere, our subconscious will alert our conscious mind. A rest period or other steps to relieve the weariness are then in order. It is interesting

to discuss the importance of seeing with an average driver and get typical responses such as: "That's what I do; that's how I drive." Most drivers do follow *some* of the basic rules *some* of the time, but too frequently they do not have the habits to make seeing performance consistently good.

Better-than-average drivers in general are the most enthusiastic about the soundness of the *seeing-habits* approach. Safety and training directors who have earned the respect of their men and managements for enviable company-wide safe driving records, have spent days with Harold L. Smith rating drivers and, in turn, being rated by Smith.

They have gone back to their jobs to practice the seeing steps they have learned and to stimulate others to use these same effective procedures. The most experienced and safest drivers often are the first to recognize the soundness of the seeing-habits approach and in turn usually are the most diligent in practicing it.[28]

### WHAT WE CAN DO NOW

Each of us can help arouse opinion and get constructive action by taking one or more of the following eight steps:

1. We can teach by precept and example that *driving is a full-time seeing job*.

2. We ourselves can learn and practice basic seeing steps until they become part of our own driving habits and until we ourselves become accident-free drivers.

3. We can help to correct the misconception that the ability to read traffic signs is the *one* major seeing requirement.

4. We can take the steps to make our own seeing job easier by calling on our eye doctor to have our vision improved.

5. We can help create awareness of pertinent facts, such as:

A. The highest percentage of accidents happen to law-abiding, sober, well-intentioned citizens, who either make driving errors or fail to see the other driver's error in time to avoid an accident.

B. An outstanding characteristic of safe drivers is their performance on the seeing job.

C. We *learn* to see correctly. Practicing correct patterns develops strong, correct habits.

6. We can encourage automobile manufacturers to keep up

the good work of easing the seeing job of drivers through continuing engineering improvements, such as eliminating glare inducing surfaces on instrument panel deck, the hood and other parts, providing even better windshield wipers and rear-view mirrors, etc.

7. Encourage continuing improvement in building better visibility into highways and traffic control devices, especially in urban areas.

8. Encourage research directed toward improving the procedures of Smith, Cummings, and Sherman for rating drivers and finding better methods of teaching others how to see and what to look for.

When these steps are taken, we may well have a much clearer line separating the willful law-breaker from the good citizen who tries to support the law but "just didn't see."

We cannot hope to solve all traffic accident problems through an extensive and effective education and research program on correct seeing habits for safe driving, but through these steps we can expect positive results such as:

1. A big step forward will have been taken toward correcting that part of the problem which deals with "*alertness*" and "*awareness*" of the driver and on his reading the traffic scene for potential hazards. This positive approach should elicit co-operation from those who do not respond to inferences of anti-social behavior and to admonitions.

2. When full recognition is given to the importance of correct seeing habits, other factors, such as willful disregard of law, can be viewed more objectively because they can be separated from the great volume of infractions which now are caused through poor seeing habits.

3. Trained, qualified observers can ride with drivers and rate them on predetermined, specific observable items which are related to seeing habits. Corrective steps can then be demonstrated by the observer, or illustrated, informative instructions dealing with the weak points can be given to the driver, or both actions can be taken.

4. Safe driving campaigns can then be more specific and meaningful.

5. More specific teaching techniques can be available for driver education.

6. More effective licensing and selection tests can be used.

Teaching drivers how to see and what to look for will get answers to some very important problems and help to clarify others. It is a positive program. It can be palatable. It need not question one's intelligence, integrity, morals or good intentions, nor need it imply weakness or guilt.

The basic procedures are specific. Accumulating evidence indicates that results will be worthwhile and gratifying.

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# Streets for the Urban Traveler

EDWARD M. HALL

*Mr. Hall has been Street Improvement Administrator of Phoenix, Arizona, since August 1960. Previously he was Transportation Research Director of the City of San Diego; junior research engineer at the Institute of Transportation and Traffic Engineering, University of California, Berkeley, and Traffic Engineer of the San Diego County Road Department. Mr. Hall holds membership in the American Society of Civil Engineers, the American Public Works Association, the Institute of Traffic Engineers, and the Highway Research Board. He is a Past Chairman of the Engineering Division of the California Governor's Traffic Safety Conference. In 1952, he received the Past Presidents' Award, Institute of Traffic Engineers.*

THE need to provide adequate transportation to serve our exploding urban population is one of the great challenges of the 60's. It is important that the urban transportation challenge be coordinated on a continuing routine and regular basis. Decisions involved in providing an urban street system cannot be made at chance meetings called at the last minute to solve some crucial problem—with some key individual inadvertently left out of the meeting.

Phoenix, Arizona, is the 29th largest city in the United States. The 1960 population was 439,170 compared with only 106,818 at the 1950 census. The area has increased at an even greater rate—from 16.4 square miles in 1950 to 188.4 square miles today. Between 1950 and 1960, Phoenix was by far the fastest growing city with a 1950 population of over 100,000—with a growth rate of 311 percent. All the many problems of city government have multiplied in number and complexity, along with the growth in population and area, during the past decade.

One of the most difficult has been the street problem. During the past decade, the City of Phoenix was able to construct only 10 miles of major arterial streets. The funds for this construction came basically from two sources—Federal aid urban and property owner participation. The City's share of the state gasoline tax was used for maintenance and for right-of-way which was not voluntarily donated by the property owners.

In addition to the lack of major arterial streets of adequate capacity, some 270 miles of unimproved local residential and industrial streets present another serious problem. Formerly, the majority of limited available maintenance funds were used to oil these unimproved streets in order to reduce dust.

With this background, the City of Phoenix entered the decade of the 60's, and decided to accept the street challenge.

### THE PHOENIX STREET PROGRAM

Phoenix has recognized the importance of providing adequate streets and freeways to serve its exploding population of nearly half a million people. This is demonstrated by the creation of a new position in the office of the city manager to concentrate on solving the urban street problem—in effect, an assistant city manager for streets. This position was filled in August, 1960. Further, this awareness is demonstrated by the active interest and support of the citizens' streets advisory committee and by the action program adopted by the city council during October, 1960.

This action program is a strong beginning toward the solution of the Phoenix street problem. Surely many problems and a great deal of work remain ahead. However, the basic steps that have been taken open the way toward the development of the adequate street and freeway system needed for the Phoenix urban area and demonstrate the need for adequate financing.

### MAJOR STREET AND HIGHWAY PLAN

On September 1, 1956, the Phoenix-Maricopa County Traffic Coordinating Committee was established. The original purpose of this committee was to coordinate the studies the community undertook as one of the pilot cities of the national committee on urban transportation. From its beginning, this committee has been composed of representatives of the United States Bureau of Public Roads, the Arizona Highway Department, Maricopa County planning and highway departments, and the Phoenix planning department and divisions of traffic engineering and research and budget.

During the course of the pilot city studies, a consulting firm conducted a comprehensive traffic planning study. The committee

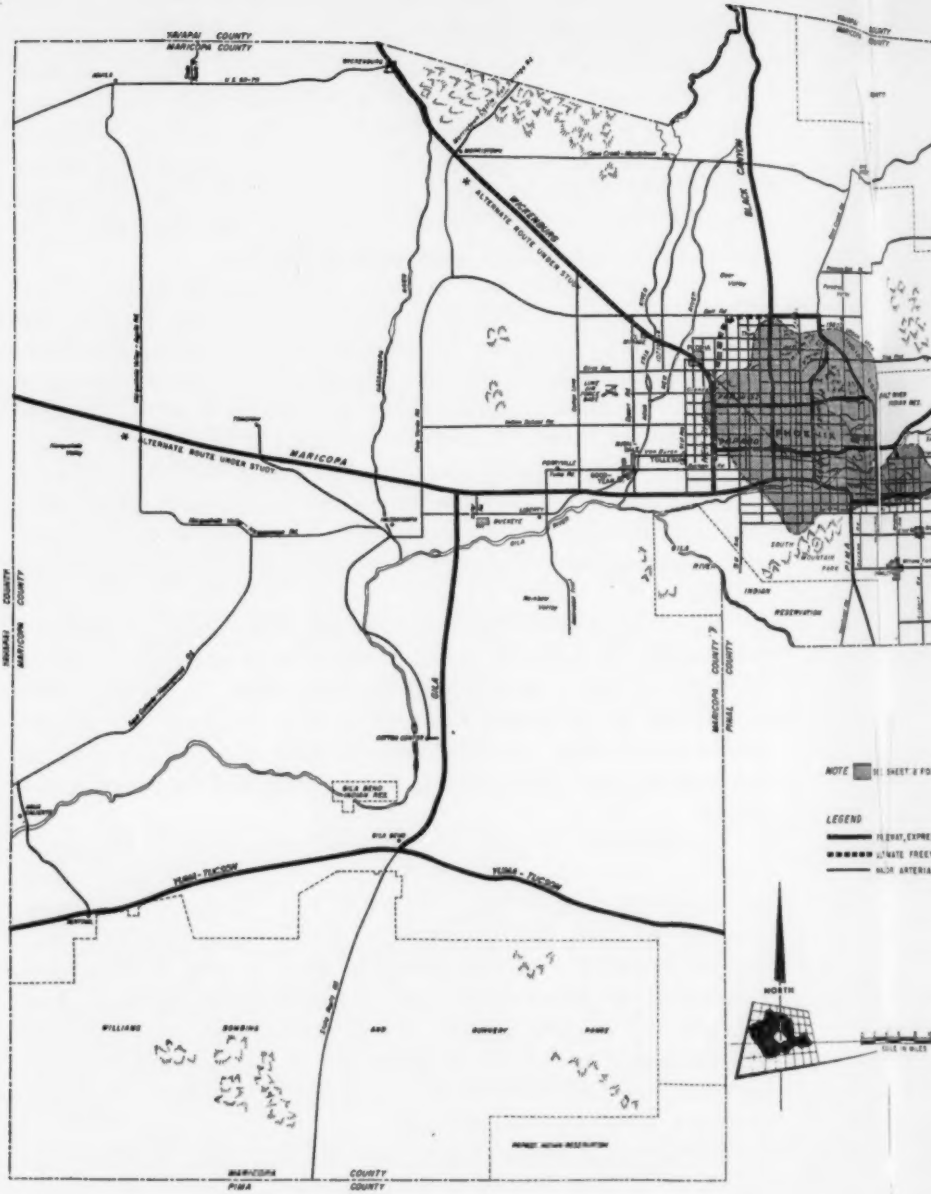
directed and coordinated the resources and efforts of the participating jurisdictions during the study. The basic land and population planning data for the traffic study were developed by the Phoenix-Maricopa advance planning task force. These studies, combined with the origin-destination survey, resulted in a report, "A Major Street and Highway Plan—Phoenix Urban Area—Maricopa County," prepared by Wilbur Smith and Associates under the general direction of the coordinating committee.

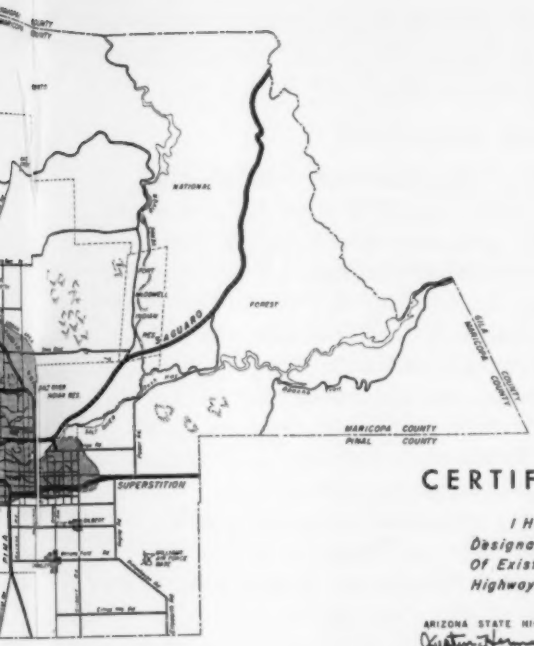
The major street and highway plan is designed to serve a horizon year population for the Phoenix urban area of 1.4 million people. Exactly when this population will occur, we do not know. By planning, however, for this population and programming as necessary for actual growth, we shall meet the needs for that population when it arrives—if adequate financing is provided. It is estimated it will cost approximately $230 million to build the necessary freeways and major arterial streets within the Phoenix urban area. The total estimated cost to provide the adequate street and highway system for Maricopa County is estimated to be approximately $360 million.

These funds would produce 140 miles of freeways and expressways within the urban area and a total of approximately 442 miles of freeways and expressways within the county. It has been estimated that the proposed county-wide freeway-expressway system would serve nearly 2½ billion vehicle miles of travel annually at the horizon year (1980). This is about one-half of the county-wide travel.

On October 24, 1960, the board of supervisors of Maricopa County adopted the recommended major street and highway plan for Maricopa County. The next day, the Phoenix city council adopted the same plan for Phoenix. Phoenix lent support to the general concepts of the county-wide plan, as well as to legally adopt those portions of the plan within the city limits. On November 15, 1960, the Arizona highway commission adopted this same plan with the exception of one route still under study. Recently this same plan has been adopted by the councils of Avondale, Buckeye, Glendale, Mesa, and Wickenburg.

The adopted Major Street and Freeway Plan is shown in Figure 1. This is an outstanding example of inter-jurisdictional


YAVAPAI COUNTY
MARICOPA COUNTY
ALTERNATE ROUTE UNDER STUDY
MARICOPA
ALTERNATE ROUTE UNDER STUDY
BLACK CANYON
YUMA - TUCSON
YUMA - TUCSON
GILA
MARICOPA COUNTY
PINAL COUNTY
YAVAPAI COUNTY
MARICOPA COUNTY
WILLIAMS
BOMBING
AND
GUNNERY
RANGE
MARICOPA COUNTY
PIMA COUNTY
INDIAN RESERVATION
NOTE
LEGEND
NORTH




## CERTIFICATE OF ADOPTION

*I Hereby Certify That This Master Plan, Designating The General Location And Extent Of Existing And Proposed Major Streets And Highways, Is Adopted.*

ARIZONA STATE HIGHWAY COMMISSION *
DIRECTOR — DATE: Nov 15, 1960

MARICOPA COUNTY BOARD OF SUPERVISORS
CHAIRMAN — DATE: Oct 24, 1960

PHOENIX — CITY COUNCIL
MAYOR — DATE: Oct 25, 1960

GLENDALE — CITY COUNCIL
MAYOR — DATE: Oct-12-60

AVONDALE — CITY COUNCIL
MAYOR — DATE: Feb 20, 1961

MESA — CITY COUNCIL
MAYOR — DATE: Mar. 6, 1961

BUCKEYE — TOWN COUNCIL
MAYOR — DATE: March 22-1961

TEMPE — CITY COUNCIL
MAYOR — DATE: May 4, 1961

SHEET 2 FOR COMPLETE URBAN AREA PLAN

END

EXPRESSWAY OR PARKWAY

ULTIMATE FREEWAY, EXPRESSWAY OR PARKWAY

MAJOR ARTERIAL STREET OR HIGHWAY

Figure 1. Major Street and Highway Plan.
Maricopa County, Arizona.

cooperation and coordination. It is this same spirit that can lead to the actual construction of the facilities shown conceptually on the adopted plans of these agencies.

### CO-ORDINATING COMMITTEE

Originally, the Co-ordinating Committee was established to guide the pilot city studies. As the full impact of these studies and the regional nature of the traffic problem crystallized, the committee recommended that it be expanded to include all the other cities and towns of Maricopa County.

A joint invitation from the chairman of the Arizona highway commission, the chairman of the Maricopa County board of supervisors, and the mayor of Phoenix was extended to the fifteen other incorporated communities to designate a technical representative to this county-wide committee. Following a welcoming lunch on December 14, 1960, this expanded committee met regularly.

With much of the basic planning completed, it is important that the co-ordination established through the Traffic co-ordinating committee be continued, and most important that it be extended to include the other incorporated municipalities in Maricopa County. Such a county-wide co-ordinating group can bring together the efforts of all to develop an adequate major street and freeway system. Thus, a primary objective of the county-wide committee is the joint review of the major street and highway plan to insure that the transportation needs of each and every jurisdiction are properly served.

As the emphasis shifts from planning a regional street and freeway system to the actual financing and construction of such a system, the degree of co-ordination and the functions of the traffic Co-ordinating Committee will change to emphasize co-ordinated action. The committee is now working to initiate procedures and recommendations for co-ordinating the orderly engineering-planning, financing, and programming so essential to the development of an integrated county-wide major street and highway system.

Members of the committee actually serve two functions—advisors to their respective jurisdictions and representatives to present the individual problems, policies and recommendations of the

individual jurisdictions on matters pertaining to the planning, financing, programming, construction and operation of an adequate county-wide transportation system.

### STREET CLASSIFICATION

A sound street classification is fundamental to the planning, design, construction, operation, and maintenance of a street or highway system. Perhaps most important, a street classification system is the key to an equitable and practicable method of allocating the responsibility for the cost of construction of street facilities.

Basically, a street or highway has two functions: to move traffic, and to provide access to abutting property. By properly combining these functions, it is possible to classify a street system.

Using the guide lines of the national committee on urban transportation, a team of planners, civil engineers, and traffic engineers produced a recommended classification map for the existing streets of the City of Phoenix. This was adopted by the city council on October 25, 1960. Figure 2 shows the street classification map. The street classification definitions are included in Appendix A.

### FINANCIAL RESPONSIBILITY

The next step in the action program was to develop a practical policy designating who is financially responsible for street improvement in developed areas of the City of Phoenix. This policy was based on the street classifications. The basic concepts used to develop this policy were as follows:

1. The function of major arterial streets is primarily to move traffic and only incidentally to provide access to abutting property.

2. The major arterial system is of city-wide importance and is a city-wide responsibility. This system will be designated in a Major Street and Highway Plan.

3. The responsibility for the cost of the development of a major arterial system should be borne by those benefiting from it—the general public.

4. It is essential that the city be in a position to program the orderly construction of streets where and when needed to develop the arterial system.

5. Significant savings can be achieved by the advance acquisi-

tion of right-of-way and the proper clearing of utilities prior to construction.

6. Efficiency of the administrative and engineering activities of the City would be improved by an orderly scheduled program.

7. The possibility of important segments of major arterial streets being voted out by the action of abutting properties should be eliminated. This would assure continuity of projects where and when needed.

8. It is important to co-ordinate the development of the City street system with the program of the Arizona Highway Department and the Maricopa County Highway Department. This can be done only by the City accepting the responsibility of developing a major street system.

Based on these concepts, Table I was developed and adopted as City policy.

TABLE I—ALLOCATION OF COST RESPONSIBILITY FOR IMPROVEMENT OF STREETS

| *STREET CLASSIFICATION* | *COST RESPONSIBILITY* | | | |
|---|---|---|---|---|
| | *Roadway* | | *Sidewalks* | |
| | *Right-of-way* | *Including Curbs* | *Replacement* | *New* |
| Major Arterial | City | City[1] | City[1] | Property Owner |
| Collector | Property[2] Owner | Property Owner and City[3] | Property Owner | Property Owner |
| Local | Property Owner | Property Owner | Property Owner | Property Owner |

Note 1: City responsibility includes the use of available Federal and State aid funds.
2: In exceptional situations where it is necessary to move four or more lanes of traffic or where unusual construction problems exist on a collector street, the City may acquire the necessary right-of-way.
3: City to pay those costs over the annual average cost of constructing a standard local street.

## STREET MAINTENANCE POLICY

A firm street maintenance policy is often a neglected stepchild of a street program. Phoenix has nearly 1,500 miles of street. Of these, approximately 560 miles are partially improved and unimproved streets. This fact, combined with increasing traffic volumes, emphasizes the Phoenix street maintenance problem. The streets

Figure 2. Major Street and Highway Plan.
Phoenix Urban Area—Maricopa County.

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Byron Reed — Dec-13-60
MAYOR — DATE

AVONDALE — CITY COUNCIL
L K Turner — Feb 20, 1961
MAYOR — DATE

MESA — CITY COUNCIL
[illegible] — Mar 6, 1961
MAYOR — DATE

BUCKEYE — TOWN COUNCIL
[illegible] — March 23-1961
MAYOR — DATE

TEMPE — CITY COUNCIL
Robert Pore — May 4, 1961
MAYOR — DATE

OPTION

Plan,
Extent
ts And

must be maintained in accordance with traffic needs and safety requirements.

On the other hand, there is an economic limit to the amount of money that can be spent on maintenance—particularly, maintenance of those streets that have not been initially improved to adequate standards. Therefore, a street maintenance policy must be economically feasible.

Again, certain basic concepts were used to develop the street maintenance policy. These are as follows:

1. Planning, design, construction, and maintenance of City streets must conform to the intent of the Major Street and Highway Plan and to the general planning approach that neighborhoods are served by local streets which are linked by collector streets to the major arterial streets. Further, that the major arterial streets in turn connect various sections of the City.

2. Major arterial streets are the principal traffic arteries serving large volumes of through-traffic and must be maintained as well as possible with funds available to carry this prevailing traffic and to attract through-traffic from the local and collector streets. Special attention must be given to major arterial streets constructed with Federal Aid in order to comply with maintenance agreements with the U. S. Bureau of Public Roads.

3. Collector streets serve considerable volumes of neighborhood through-traffic and must be maintained by the public to carry this traffic. However, the level of maintenance should not be so high as to attract traffic from major arterial streets.

4. Local streets, after construction by abutting property owners to meet standards established by the public agency, should thenceforth be maintained by the public. Where streets are not improved, maintenance should be the minimum that permits safe use by normal neighborhood traffic.

5. Priorities shall be given in the following order:

Federal aid major arterial streets.
Other major arterial streets.
Collector streets.
Local streets.

These concepts led to the development of the following table by Fred Glendening, the public works director. This table and the

special conditions that follow were adopted by the city council as its policy for street maintenance on October 25, 1960.

TABLE II—STREET MAINTENANCE POLICY

| *Type of Construction* | *Maintenance Level by Street Classification* | | |
|---|---|---|---|
| | *Major Arterial* | *Collector* | *Local* |
| Type A—Paved | | | |
| Curb and gutter | 1, 2, 3 | 1, 2, 3 | 1, 2, 3 |
| No curb and gutter | 2, 3, 6, 8 | 2, 3, 6, 8 | 2, 3 |
| Type B—Bituminous Surface Treatment (BST) | | | |
| Curb and gutter | 1, 2, 3 | 1, 2, 3 | 1, 7* |
| No curb and gutter | 2, 3, 6, 8 | 2, 3, 6, 8 | 7* |
| Type C—Oiled | | | |
| No curb and gutter | 3, 4, 6, 8 | 3, 4, 6, 8 | 7* |
| Type D—Graded Only | | | |
| No surface treatment | 4, 6, 8 | 5, 6, 8 | 5* |

*Maintenance Level Code:*

1. Sweep gutters and intersections.
2. Resurface or sealcoat as needed.
3. Patch with mixed bituminous material or slurry mix.
4. Oil and re-oil (including extra width) as necessary for traffic demand.
5. Sprinkle and grade for reshaping; no intermittent sprinkling.
6. Sprinkle and grade shoulders; no intermittent sprinkling.
7. Fill pot holes with crushed disintegrated granite or gravel.
8. Mow shoulder area.

*Where a local street is carrying in excess of 1,000 vehicles per day and where, in the opinion of the Director of Public Works, such street is seriously deteriorated to the extent that it cannot be economically maintained as authorized herein, the Council may authorize special maintenance procedures.

Because of the serious nature of the unimproved local street maintenance problem and the related dust problems on these streets, and the serious limitations of the city funds, the maintenance policy includes the following statements:

1. Property owners shall be encouraged and aided in every practical and expeditious manner to form local street improvement districts.

2. Property owners may, at no expense to the City, spray dust-control oil on local streets after securing a City permit to do such work in accordance with City specifications.

3. When, in the judgment of the director of public works, the

public safety and welfare is jeopardized by the deteriorations of unpaved local streets, the city council may authorize the public works department to arrange for the preparation of street improvement plans and a proposed resolution of intention to improve these seriously deteriorating streets where the property owners have not petitioned for these improvements.

4. In the event that a street improvement project is not protested out during the protest period following the adoption of the resolution of intention, the City will continue to maintain the street as cited above, and it may control excessive dust until start of construction.

The results of the city council's bold and forward-looking decision of early 1960 to stop oiling unimproved streets, combined with this maintenance policy are impressive:

1. The limited amount of available maintenance money has been used to resurface 22.1 miles of major arterial and collector streets and to seal 60.4 miles of streets. This program would have had to be significantly reduced if the City had continued to spread oil on the unimproved streets at an estimated additional cost of nearly $1 million per year.

2. So far this fiscal year, approximately eighty percent of the maintenance money has been expended on the major arterial (64 percent) and collector (16 percent) street systems. These streets carry over eighty-five percent of the vehicle miles that are traveled in this city.

3. Maintenance monies are being utilized where they will do permanent good. The oiling of dirt streets is, at best, a very temporary palliative.

4. The residential improvement district program is well under way. The creation of a new position in the Division of Engineering to concentrate on assisting the public in the formation of improvement districts, combined with the maintenance policies, has increased this program more than tenfold over previous years—from approximately $180,000 to over $2 million worth of local street improvement contracts per year. This latter figure is a significant amount of paving.

A significant tool has been developed by the public works department to assist field crews in this maintenance policy. All the

streets in the City have been inspected to determine which of the four types of construction shown in Table II applies. This information has been placed on maps which have been distributed to all street maintenance crews. Thus, the men in the field have a clear policy that is easy for them to follow.

### CONSTRUCTION PROGRAM

As the first program designed to implement the adopted major street and highway plan, the city council adopted the *Street and Highway Capital Budget—1960*. This budget of $7,816,000 includes the construction of nineteen miles of four-lane major arterial street, plus the improvement of two major intersections in co-operation with the Arizona highway department.

The budget includes $6 million of the street and highway improvement bond portion of the $70 million bond issue for growth approved by the citizens of Phoenix in May, 1957. The balance of the funds is basically Federal aid with a small amount of property owner assessments for new sidewalks. All of the street improvement projects included in the budget will be completed or under contract by June 30, 1962.

Here, again, the results of the new policies enabled the City to move. The first bids were opened within thirty days and the first contract awarded within five weeks of their adoption. One project is already completed and three major arterial street projects are under construction. The total cost of these four improvements is $1,789,000. Three and one-half miles of one other major arterial street have been reconstructed with funds from the $6 million bond issue.

The *Street and Highway Capital Budget—1960* includes the plan, policies, projects, and financing. Thus, a significant framework is established on which to base future capital improvement programs for streets and freeways.

### ADVANCE TRANSPORTATION PLANNING TEAM

A major street and highway plan is basically a presentation of a long-range goal. Following the appropriation of the necessary funds, the final stage of implementing any of the facilities shown on the plan is the preparation of detailed construction plans and specifica-

tions, and then construction. Before undertaking preparation of detailed construction drawing, there remains much to be done in the field of advance engineering-planning. Many problems will be solved and much time saved by the establishment of such a function in local governments on a continuing basis.

The actual development of a comprehensive regional transportation system involves many administrative and technical skills. Five key elements are planning, traffic engineering, engineering design, economics, and coordination. In order to make the maximum use of these elements, the establishment of a small group of technically qualified people has been authorized.

This advance transportation planning team is working together in one office on a full-time, continuing basis, separate from the day-to-day activities of their departments. The persons assigned to this team are representatives of their departments and form a two-way street of communication between the departments and the team. The team is designed to produce answers for management.

This team was placed in operation in January of this year. Already it has produced significant results. A right-of-way width map for the entire city, based on the concepts of the adopted master plan and the street classification map, has been prepared. This map has been reviewed by the division and department heads and presented to the city council. It is expected that this map will be adopted as part of the city zoning ordinance and can then be distributed throughout the city so that all personnel will have the same information with which to deal with the public. The team has also completed its first specific study of a difficult surface street and land use problem.

The advance transportation planning team is now working on its first large-scale transportation planning assignment. This is the development of a traffic circulation plan for the downtown area of Phoenix in conjunction with the studies of the planning department.

Following that, the team will attack other technical advance planning problems that will develop as the street improvement program proceeds. This will include general design of major arterial streets at critical locations; location of freeways; location of freeway on- and off-ramps and their effect on the City and its street system.

It is hoped that other agencies that have co-operated in the de-

velopment of the Major Street and Highway Plan will soon assign representatives to the team in order that it can become a truly metropolitan area advance transportation planning and coordinating team.

## FUTURE PROGRAM

Recently, the City of Phoenix prepared a 10-year program for the construction of urgently needed major arterial streets and freeways. This program envisioned the construction of approximately 106 miles of major arterial streets at an expenditure of approximately $50 million—concurrent with the early acquisition of rights-of-way for the freeway system and the construction of eight miles of freeway by 1971. The program further envisioned the City participating in construction of some 70 miles of collector streets at a cost of approximately $3 million during this same period.

The total program would construct 185 miles of streets and freeways at an estimated cost of $91 million. The program was based on the assumption that there would be at least $5 million per year of "new money" available for street improvement. Further, the program envisioned $26 million in bonds to be supported by the proposed new revenue source. The program was designed to follow the current adopted major street and highway budget which is constructing 19 miles of major arterial streets at a cost of $7.8 million.

The 10-year program would provide the City with a well-developed arterial street system by 1971, as shown by Figure 3. Equally important, it would enable the City to gain a healthy start in the acquisition of rights-of-way for the freeway system, as well as to build eight miles of freeway.

It is the intention of the City to embark upon this program as soon as adequate financing is available.

## FINANCING

To provide streets for the urban traveler, the City must have two basic ingredients—organization and financing. The preceding portions of this paper have summarized the administrative organization. The City of Phoenix has established a top-level administrative position to concentrate on the street problem. The City has

adopted a long-range major street and highway plan, street improvement and maintenance policies based on sound concepts, and a capital budget to implement the first of what is hoped will be a series of programs to implement the master plan, and has established a regional coordinating committee and an advance transportation planning team to produce specific answers for top management. A proposed ten-year major street and freeway construction program has been carefully developed to reflect the planning and policies that have been adopted.

Further, the organization of two city divisions concerned with street problems, as well as many specific administrative processing matters, are under active study. Thus, the basic administrative organization for a street and freeway program is completed or in sight, and we must now turn our attention to financing.

Phoenix receives approximately $1 million a year as its share of the state gasoline tax, which in Arizona is five cents a gallon. Further, Phoenix has been receiving approximately $500,000 a year from Federal aid urban funds. As has been previously mentioned, the city has $6 million gasoline tax revenue bonds from the 1957 bond program which it is using in its present construction program. In addition to this, the City is spending approximately $3 million a year for street maintenance, traffic engineering, and street lighting. Funds for these activities come largely from the general fund of the city.

In 1958, it was estimated by the consultant that it would cost the City of Phoenix approximately $120 million over a twenty-year period to construct its portion of the system envisioned in the Major Street and Highway Plan. As the City grows, so will this figure. The ten-year program developed in 1961 calls for an expenditure of approximately $91 million. These are large sums of money by any standard. Further delays in beginning this program will undoubtedly increase the cost.

Phoenix should be spending at least $6 million a year at this time for construction of major arterial streets and freeways if it is to accomplish its portion of the major street and highway plan. The combined rate of expenditure of state, county, and city governments in Maricopa County for constructing major streets and highways should be a minimum of $20 million a year to build the

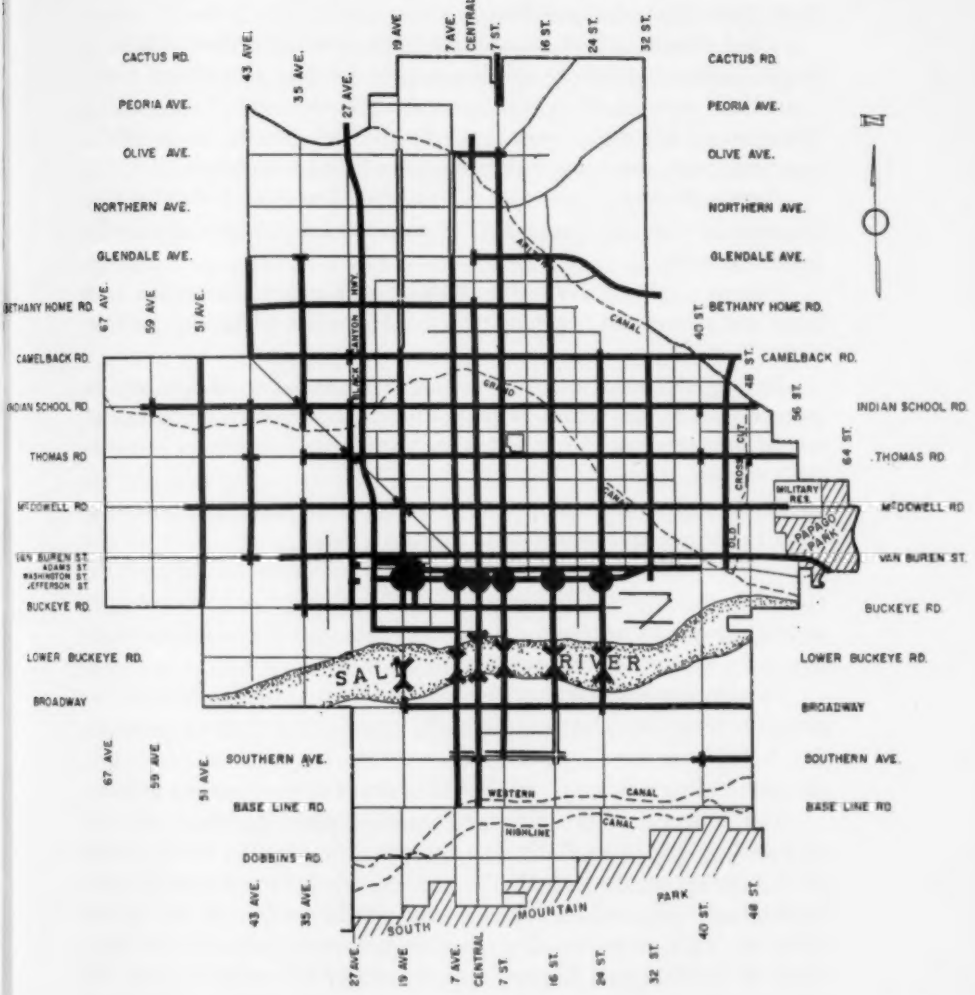


Figure 3. Major Arterial Streets.

needed transportation system in the next twenty years. Existing revenues of the cities and the county are completely inadequate to meet these rates of expenditure.

Thus, it is clear that, in addition to its present revenue, Phoenix needs approximately $5 million a year in *new money* from some source not now in existence. Several alternate methods of raising this amount of money were carefully studied. Briefly, some of the more seriously considered alternates are listed as follows:

*Increase the property tax rate:* A $1.25 per $100 assessed valuation increase in the city property tax rate would produce about $5 million a year.

*Increase City's sales tax:* An increase in the city's sales tax rate from half percent to one percent would produce about $4,500,000 annually.

*Increase the motor vehicle in-lieu tax:* A doubling of the motor vehicle in-lieu tax would provide adequate funds for Phoenix. It would be necessary to triple this fee to provide funds for a county-wide system.

*City gasoline tax:* Adoption of a city three-cent gasoline tax would produce an estimated $4 million a year.

*County-wide three-cent-per-gallon gasoline tax:* This would provide an estimated $5,200,000 per year for Phoenix. Most important, it would provide financing for the other cities and the county to construct the needed county-wide system.

Careful consideration of the practicality, administrative costs, potential evasion, relation to benefit, equity, and revenue production led to both the City of Phoenix and Maricopa County strongly recommending a county-wide gasoline tax of three cents per gallon.

The concepts of the proposed county-option gasoline tax are attached as Appendix B. Such a county-wide gasoline tax of three cents a gallon would provide the needed new revenues to solve the local street and traffic problems and would be fair to the using motorist. This proposed new gasoline tax would cost the average motorist in Maricopa County approximately fifty cents a week. It was estimated that, on completion of the system, he would save approximately eighty-four cents per week in operating costs.

This proposed enabling legislation was submitted to the state legislature during its 1961 session. It was hoped that this essential

financing would already have been provided. Unfortunately, it is not. However, there is widespread support of this proposal. The county board of supervisors made the original proposal, supported by official action of the councils of Avondale, Chandler, Glendale, Mesa, Scottsdale, and Wickenburg, as well as Phoenix. This represents ninety-four percent of the people of the County.

Further, many organizations supported the proposed enabling legislation—the Council-appointed Citizens' Streets Advisory Committee, the Phoenix Chamber of Commerce, the Downtown Merchants' Association, the 1961 Phoenix Growth Committee, the Road Committee of the Maricopa County Farm Bureau, and the League of Arizona Cities and Towns, to name a few.

The extreme gravity of the street financial problem can be understood by comparing the recommended ten-year major street and freeway construction program to the program that Phoenix can presently finance. During the next five years, the recommended program would have expended $41 million to construct over fifty-one miles of major arterial streets, as well as investing nearly $8 million in the advance acquisition of rights-of-way for the urgently needed freeway system.

This is contrasted to a $9.5 million program which can be financed from existing funds plus $3 million in gasoline tax revenue bonds that can be issued in the next five years. This $9.5 million program will construct less than 15 miles of major arterial streets and will completely eliminate any city freeway right-of-way acquisition and/or construction during the next five years.

## SUMMARY

The Bureau of Public Roads, Arizona Highway Department, County of Maricopa, and Phoenix jointly built a strong foundation for a county-wide street and freeway system with the formation of the Phoenix-Maricopa County traffic coordinating committee nearly five years ago. This technical committee is now county-wide in scope and has produced a major street and highway plan that *Remembers the urban traveler.*

The Arizona Highway Department has nearly seven miles of freeway open to traffic in this urban area. The Maricopa County Highway Department has constructed several major arterial high-

ways to modern standards in the urban fringe areas—many miles of these streets have since been annexed.

Phoenix has recognized its street problem. This is emphasized by the widespread support of citizen groups for the street program which has been developed and which includes the construction of nineteen miles of major arterial streets. The city is organized, has plans, programs and policies which would enable it to embark upon the major street and freeway construction program that is so badly needed.

After much joint study by the County of Maricopa and the city of Phoenix, a means of financing has been developed and submitted to the state legislature. Efforts are now under way to develop the additional organized public support which is necessary to insure that adequate means of financing are provided.

With these tools, and with the continuing public support and coordinated technical cooperation that have been established, the Phoenix metropolitan area looks forward to meeting the challenge of providing streets for the urban traveler.

## APPENDIX A

### CITY OF PHOENIX, ARIZONA

### Street Classification System

1. *Freeway-Expressway* provides for the expeditious movement of large volumes of through-traffic between areas and/or across, around or through the city. A freeway or expressway is a divided arterial highway with full control of access and is not intended to provide direct land access services. A freeway will have complete separation of conflicting traffic flows while an expressway may have few or no grade separations and may be a stage development toward a freeway.

2. *Major Arterial Street and Highway* provides for traffic movement between areas, and across portions of the City, and connects to the freeway-expressway system, and secondarily for direct access to abutting land. Major arterials are therefore subject to necessary regulation and control of parking, turning movements, entrances, exits and curb use. Major streets are normally divided arterial roadways, and may have some control of access.

3. *Collector Street* provides for traffic movement within areas of the City and between major streets and local streets and for direct access to abutting property.

4. *Local Streets* provides for direct access to residential, commercial, industrial or other abutting land for local traffic movements and connects to collector and/or major streets.

NOTE: *Parkway* provides a scenic and/or intensively landscaped appearance to any of the above street types, individually or in combination. Normally the parkway system will provide access to and connect the parks and scenic areas and traffic service through such areas.

## APPENDIX B

### CONCEPTS OF PROPOSED PERMISSIVE ENABLING LEGISLATION FOR COUNTY MOTOR VEHICLE FUEL TAX

1. Legislation to be applicable only to counties of over 600,000 population.

2. Legislation to be permissive on a county-option basis up to three cents a gallon of fuel with the same exemptions as are now provided by state law.

3. Funds to be collected and distributed by the state motor vehicle superintendent to the county treasurer by established administrative procedures used to determine the county of sale or use.

4. Prior to allocation of these funds, each jurisdiction in the county and including the county would be required to file its current adopted major street and highway plan with the county recorder and to furnish an informational copy to the state highway commission and to the county board of supervisors and the county treasurer. Each jurisdiction may amend its adopted major street and highway plan as it deems necessary.

Following compliance with the above requirements, funds to be allocated by the county treasurer to the several cities and to the county on the basis of the percent that the population of each jurisdiction is to the total population. The decennial census as adjusted annually each July 1 for annexations and incorporations shall be the basis of determining population except that provisions shall be made for special census every five years.

5. The money to be paid into a special fund, and its use to be limited to the purchase of right-of-way, engineering, and construction or reconstruction of major arterial streets, highways, expressways and freeways included in the adopted major street and highway plan of the jurisdiction spending the money. All existing anti-diversion laws shall apply. Each city and county receiving funds under these provisions would be responsible for preparing an annual report of funds received and the purpose and amount expended. Following approval by the respective council or board of supervisors, the report shall be recorded with the county recorder prior to September 30 of

each year. The report shall include a statement that the funds allocated under these provisions were expended to develop the system shown on the adopted major street and highway plan of the reporting jurisdiction.

6. The funds derived from this source shall be subject to bonding and may be used for debt service of bond issues for the purposes specified above. Protection to bond holders would be the same as provided in present motor vehicle fuel tax laws.

7. Any funds which cannot be allocated due to the lack of an adopted major street and highway plan would revert to the fund established by the county treasurer and be reallocated the following year to each respective jurisdiction on the same basis as part of the annual allocation. Any jurisdiction, after having complied with the above provisions, may carry over or otherwise accumulate the funds allocated to it and could include in the annual report the amount and purpose of such accumulation.

8. The county motor vehicle fuel tax may be established by the board of supervisors.

9. This legislation to be effective as soon as possible but providing that no tax shall be imposed prior to July 1, 1961.

# Use and Misuse of Traffic Signs

JAMES E. P. DARRELL

*Mr. Darrell, Traffic Engineer, Minnesota Department of Highways, has served the Department for thirty-six years. He has headed the traffic engineering function since 1948. He is a member of the National Joint Committee on Uniform Traffic Control Devices, and Chairman of its Subcommittee on Signs. He was Co-Chairman of the Special AASHO Committee on Interstate signing, and is presently Chairman of the Special Subcommittee, of the AASHO Committee on Traffic, on Changes in the Interstate Manual. He is a member of ITE, Highway Research Board, Department of Traffic and Transportation.*

ONE of the serious problems today, from the viewpoint of drivers of motor vehicles, is the manner in which signs and other traffic control devices are used on various road systems, and in different jurisdictions.

In spite of the efforts on the part of many groups to achieve uniform standards, and although considerable progress has been made to that end, there are still wide differences in designs and usages of traffic signs, markings, and signals in various parts of the country.

As one travels through cities and states and observes the variations in method and equipment in guiding motor vehicle traffic, it would appear that many jurisdictions are either unaware of or unconcerned with the practices in other jurisdictions.

## PROPER RATHER THAN ADDITIONAL SIGNS

In earlier times the lack of uniformity, in fact the lack of signs themselves, was perhaps not too serious. There were comparatively few long distance travelers by motor vehicle. Most highway travel consisted of relatively short trips, and involved drivers who, being thoroughly familiar with the area, required a minimum of signing for either guidance or control. Traffic volumes were usually low, and, except for a few destination names at crossroads or junctions, there was little need for very many signs. Even on the heavier traveled urban arterials the signing practices were relatively simple compared with present-day requirements.

Road signs are essential on all roads that serve any appreciable amount of public travel. They are necessary to the safety of both

vehicle traffic and pedestrians, and to encourage the most efficient movement of traffic with a minimum of conflicts and delays. There is ample evidence that the public supports the greater use of traffic signs.

In fact, this increased sign-consciousness on the part of the public may bring to us one of the more difficult problems that needs to be solved. In some places there are increasing demands for more signs. Often the need is for proper signing rather than for additional signs.

It is not uncommon for traffic authorities to be besieged by organizations or individuals to install more signs. Apparently some persons think that the more signs there are, the better traffic will behave. If one sign is effective, two will be twice as effective. If this were true, the solution to the accident problem would be less difficult since all that would be needed would be to erect more signs.

Fortunately, there are others who hold to a different view. They suggest that traffic will move more safely and efficiently with fewer signs. They support the position that it is not the number of signs so much as it is a question of getting the right sign in the right place.

There is considerable experience to show that merely adding more signs, even if the signs themselves are appropriate, it not necessarily the wise action. More and more there is a growing feeling that instead of adding more signs more effort should be directed toward the use of better signs. It is how signs are used and not the number of them that determines their effectiveness.

Comments and letters received from private citizens indicate a growing public concern that the use of roadway signing is being overdone, that in some places the excessive use of signs has been such as to increase rather than decrease the confusion and difficulties confronting the driver on today's crowded highways. They suggest that the driver already has a complex enough burden without adding to his problems by the excessive use of signs.

## NEED FOR UNIFORM PRACTICE

The need for uniform practices in signing of streets and highways was recognized over forty years ago when officials of neighboring states began to be interested in what their neighbors were doing about highway signs. In some of the regional groups, studies were

conducted to determine how best to convey the needed information to the drivers of vehicles.

Some organizations of public officials appointed committees to study the problem and to make recommendations as to the design of some of the more commonly used signs, and to suggest rules for their usage. The Mississippi Valley Association of State Highway Officials was one of the groups to make such a study.

Its committee recommendations included the black and yellow octagon for the STOP sign, the black and white rectangle with longer dimension vertical for the regulatory signs, the black and yellow diamond shape for the SLOW sign, and the black and white rectangle with longer dimension horizontal for the destination and informational signs.

A few years later the American Association of State Highway Officials published their first manual which included the basic shapes and colors as listed above.

In 1924, because of the growing concern for the increasing number of traffic accidents, Mr. Herbert Hoover, then Secretary of Commerce, called together a large group of citizens and public officials in what was the first meeting of the National Conference on Street and Highway Safety. At this conference appropriate committees gave much attention to the need for a better and more uniform use of traffic signs.

A significant action by the conference was the setting up of a joint committee representing both the conference and the American Association of State Highway Officials to carry on further studies and to develop a national manual of uniform traffic control devices.

The manual on Uniform Traffic Control Devices for Streets and Highways, first published in 1934, was the result of the work of this committee.

Since its first publication, the national manual[1] has been amended, revised, and supplemented several times to keep it up to date, and to meet newly developing needs.

Also the make-up of the joint committee has changed. First the Institute of Traffic Engineers was added as a parent body. More

1. Manual on Uniform Traffic Control Devices for Streets and Highways, Bureau of Public Roads.

recently two more "parents" have been invited to designate representatives on the committee and have accepted. At the present time the 25-member committee works under the auspices of five parent groups, namely: American Association of State Highway Officials, Institute of Traffic Engineers, The National Committee on Uniform Laws and Ordinances, The National Association of County Officials, and The American Municipal Association. The first three groups each have seven representatives on the committee. The last two each have two representatives. The new 1961 edition of the Manual on Uniform Traffic Control Devices is the result of the deliberations and studies of this newly enlarged committee.

### PURPOSES OF SIGNS

Traffic signs provide a means of communication by which drivers may be able to orient themselves as to where they are, how to get to their intended destinations, and furnish information on special regulations or warnings to aid them to complete their journeys more conveniently and safely. The motoring public has become so accustomed to traffic signs that it may have become overly dependent upon them, and perhaps has lost sight of the real purposes for which they are installed.

While the needs of the driver should form the principal basis for installing a sign, it appears that this is not always the case. In some areas it appears that other considerations have tended to supplant drivers' needs as the justification for sign installations. In fact, the driver may become the victim instead of the beneficiary of highway signing if a current trend toward too many signs is not controlled.

In our efforts to do all possible to help the vehicle operator, we may have, in some cases, only added to his troubles. There are situations where the driver is confronted by so many and sometimes conflicting regulations and directions that it is almost impossible, without stopping to study the signs, to determine what he is supposed to do or in what direction he should go.

Much of the over-signing and other misuse of signs results from the fact that the traffic authority hesitates to deny an unwarranted request from a reputable citizen or group for the installation of a specific sign. Often the granting of one such request leads to another

and, one by one, the "forest" begins to develop. Many of the signs requested have little relation to traffic safety or to the needs of the driver, but may be only for the purpose of satisfying local pride or ambition. Some of them are little more than advertising signs masquerading under the cloak of official signs, and thereby enjoying a location on the highway right of way not available to other advertising signs.

### MISUSE OF SIGNS

Not all requests are of this type, however. Many indicate a sincere concern for a traffic hazard (real or imagined) or other condition that the person requesting the sign believes can be corrected by the installation of the specified sign. Perhaps he has seen such a sign at another location, or in another jurisdiction, and was impressed with it to such a degree that he is confident it would be effective everywhere.

It should be noted here that not all sign misuse is the result of citizen requests. Much of it results from a tendency in some areas to treat signs and signing as unimportant, and something that we can take or leave at will. Or it may result from the practice in some jurisdictions of leaving the question of signing to chance—by not considering it an essential element of the roadway itself[2] and entitled to the same care and technical skill as is the design and construction of the highway itself. The proper use of traffic signs cannot and should not be left to chance or the use of them delegated to untrained personnel.

There is a real need for more educational work among those having responsibility for the design and use of traffic signs. Unless this group can be encouraged to adopt good signing practices, there can be little hope for any general improvement. It is believed that most of them could and would make greater effort toward more effective signing if they received the proper support both for the installation only of needed signs, and the denial of requests for superfluous or other improper signing.

The use of warning and regulatory signs where not fully warranted can do a great deal of harm and at least partially destroy the

2. Correlation of Geometric Design and Directional Signing, Webb, Dentino and Israel, California Division of Highways, 1959.

effectiveness of the same signs in the same community in locations where there may be a real need for them. Frequently, a particular sign installation is requested at a location only because a similar sign has been said to be effective in helping a different situation in a neighboring community.

Occasionally a sign installation is requested without reference to any special location, but merely because the person requesting it thinks it is a good sign and his town ought to have one. This has happened. Such improper and unwarranted use of traffic signs must, of course, be resisted and prevented. There can be no justification for such misuse.

## DRIVER NEEDS

Under modern traffic conditions the needs of the driver should determine what signs are to be installed and where they are to be placed. Signs which do not help traffic to move more safely and smoothly should not be permitted on the street or highway.

The erection of other signs, however worthy the purpose of such installations, can only serve to increase driver confusion and to detract from the effectiveness of those that perform needed service to the vehicle operator.[3]

The major problem in sign control exists, unfortunately, on the more heavily traveled routes where the use of needed regulatory and guide signs is also the greatest. In such circumstances the use of nonessential signs is not only harmful, but unjustified. These are the arterials into and through urban areas. They are the roads and streets of greatest concern to local civic and other groups. On these routes, local organizations want to advertise their existence and their meetings.

These are the streets where special signs, having little to do with traffic guidance or regulation, are most frequently requested. It is here where official signs meet their heaviest competition for driver attention from large and small advertising signs just outside of the right of way. And it is here that the driver may have the greatest need for the official signs.

3. Driver Needs in Freeway Signing, a Research Project conducted for the California Department of Public Works, Division of Highways, by the Automotive Safety Foundation, Washington, D. C., 1958.

Experience supports the often-stated principles that, for the greatest effectiveness, regulatory and warning signs should be used sparingly, but that guide and essential information signs can be used more liberally without detracting from their usefulness. Blind adherence to this principle can, however, be harmful.

### SIGNING PRINCIPLES

Unless used with discretion, this rule can only add to the problems of the driver if he is confronted with more signs in a group than he can readily read and comprehend as he moves along at the average prevailing speeds.

The driver does not have time to search for the sign that he is supposed to obey. Rather the sign must be located where it alone will attract his attention at an appropriate distance. Repetition in signing is not to be criticized. It is necessary. But the spacing between signs is very important.

The National Manual on Uniform Traffic Control Devices contains the following provision:

"Care should be taken not to install too many signs, especially those of the regulatory and warning types which, if used to excess, tend to lose their effectiveness. A conservative use of regulatory and warning signs is recommended. On the other hand, a frequent display of route markers and directional signs to keep the driver informed of his location and his course will not lessen their value."

Normally, except for intersectional controls where needed, signs on the approaches to intersections should be devoted primarily to guidance. In these areas, miscellaneous informational signs should be avoided. The necessary regulatory signs should be held to a minimum. Signs giving various kinds of additional information when used should be well away from intersections with liberal spacings between individual signs. Nonintersectional regulatory signs should be situated beyond intersections unless they are of a type that applies only to specific locations, in which case they must, of course, be placed at the point where the special regulation is to be effective.

All signs should be designed for quick and easy legibility at normal distances in advance of the sign. These distances will vary somewhat as speeds increase. For urban areas 250 to 300 feet are

usually adequate, but in rural areas these distances should be materially greater.

The excessive use of warning signs is perhaps a more common fault. The too frequent use of warnings where relatively little warrant for their use exists develops in the driver a feeling that the signing is meaningless and need not be heeded. Such usage is like a cry of *Wolf*, and can reduce the effectiveness of those signs properly placed and for which there is full justification and, in fact, a real need.

It is suggested that where sight distances are appropriately adequate, and where the special hazard or condition for which the sign is placed is itself clearly visible to the approaching driver for a safe distance in advance, that the use of the warning sign might very well be questioned.

Such situations may often present difficult questions for decision for the traffic engineer. Often the public, at least well-meaning citizen groups, will bring pressure to bear upon the traffic authority for the installation of signs in locations where there is really no justification.

As a rule no study has been made or professional advice obtained as to the need for such signing. Frequently the request is based largely on a misunderstanding of the real problem. Usually the person or group making the request is thoroughly convinced that the erection of that specific sign will eliminate the hazard.

A peculiar but almost inevitable characteristic of individuals or groups demanding the placement of regulatory or warning signs is their utter confidence in the effectiveness of such signs. They always, according to their statements, watch for such signs themselves, and they always, so they say, drive in accordance with the regulation or warning that is posted.

### INFORMATIONAL SIGNS

Studies of driver conformance to posted regulations and warnings do not indicate such a degree of effectiveness as their statements suggest. In fact some of these studies show many discrepancies between what individuals or groups say they do and what the same individuals or groups actually do. These are, perhaps, phenomena that we must expect, but which should cause us to be a little more

cautious in agreeing to erect the signs without first determining that such installations will in fact be helpful. To do anything else can only result in the more serious error of the over-use of such signs.

In the case of guide or informational signs, the rules are not quite so specific nor restrictive, and opinions are apt to be more varied. Guide signs differ from regulatory and warning signs in that they do not lose their effectiveness or value to the same extent from over-use. In fact their liberal use has been found in some places to be beneficial. Repetition, a most useful device, helps in guiding traffic.

This principle of repetition is, of course, a major element in advertising campaigns. Repetition is an important element in the dissemination of information whether in school, in advertisements, or on the highway. However, too many different signs with varying legends and different kinds of information can be confusing.

Thus, in thinking about the proper number of signs, we must distinguish between cases where there is repetition and those where there is little or no repetition. Thus the rule suggesting the liberal use of guide signs must be used with discretion. The fact still remains that where several signs are used in close proximity to each other, each individual sign is reduced in effectiveness.

The critical area in guide signing is reached when many or several signs are grouped together in such close proximity that no sign is clearly distinguishable from the others. In such cases, all of them lose much of their value. A driver, in such cases, may be seriously handicapped in getting the help which he needs if the sign he is looking for is hard to find among a number of other signs in which he has no interest.

These problems have been seriously considered by the committees responsible for developing and preparing national signing standards. Admittedly, no exact formula can be written that would provide the best arrangement in all conceivable situations.

Careful attention to signing warrants, and the avoidance of all but the necessary signs based upon studies of driver needs at each location, can do much to improve driver conformance and eliminate much of the driver confusion now existing.

Effectiveness of official traffic signing can also be adversely affected, and sometimes almost nullified, by clusters of advertising

signs in the vicinity, even though not placed directly on the highway right of way. Good highway or street signing requires the placement of official signs where they will not be interfered with by roadside conditions, or, if that is not practical, arrangements should be made in the roadside conditions to eliminate or minimize the interference.

### EXCESSIVE USE OF SIGNS TO BE AVOIDED

As has been suggested, the most serious result of oversigning is its effect on the drivers of vehicles. When signs are properly designed for easy legibility and installed at spacings that prevent the interference of one sign with another, the driver will have no difficulty in reading and understanding each message.

To achieve such results, sign legends must be short and clear. The operator of a vehicle under 1961 driving conditions must depend upon short glances to read and understand the message intended for him. We cannot be sure that all drivers will glance at the sign at the same distance away or for the same period of time.

It is necessary, therefore, that each sign be legible to a driver for a considerably longer period than it takes him to actually read it. It is generally accepted that signs should be designed for a reading time of eight to ten seconds at the prevailing or 85-percentile approach speed on the highway.

This, admittedly, is not always attained, but it is likely that much of the lack of effectiveness of so many of the signs which are erected may be the lack of sufficient reading time. The reading time for each sign depends not only on sign location, but more likely simplicity of legend and size of letters.

### CONCLUSION

An example of the application of this principle is the provision in the Interstate Sign Manual[4] of the American Association of State Highway Officials, approved by the Federal Highway Administrator. This specifies not only the minimum letter and numeral sizes for use on each sign but it also includes the provision that "In no case shall guide signs placed in advance of the interchange deceleration lane be spaced closer together than 800 feet."

4. The American Association of State Highway Officials Manual for Signing and Pavement Marking of the National System of Interstate and Defense Highways, 1958.

It is apparent that there are many who hold to the theory that all problems or deficiencies in traffic movement or accidents can be corrected by erecting a sign. Unfortunately, this kind of thinking is not found only among the general public or the "nonprofessionals," but apparently is concurred in by the responsible officials in some jurisdictions. Likely, the official responsible for traffic signs will be, in the future as in the past, occasionally required to install a sign for which he knows there is no proper justification, due to situations beyond his control.

But excessive use of signs, and especially the unnecessary and harmful grouping or bunching of signs, can generally be avoided if there is a sincere desire to conform to the established standards for good practice which are provided in available manuals.

There is a limit to the amount of legend, or the number of signs, that a driver can read as he controls his vehicle along the road. All of his time cannot be devoted to reading signs. He must watch the road ahead for other vehicles or pedestrians.

He must be alert to other traffic to the sides or to the rear. He must, or at least should, pay some attention to the proper functioning of his vehicle, its signals and various gauges on the dash. Driving is a full-time job and traffic signs should be designed and located to require as little of the driver's direct attention as is possible and still provide him with the information which he needs to enable him to complete his trip safely, conveniently, and without confusion.

We need to pay more attention to the problem of excessive signing and take steps to avoid such misuse. Such a program could result in more pleasant driving, a substantial saving of the cost of unnecessary signs, and, above all, better information to the driver.

# Investigating Traffic, Highway Events in Relation to Driver-Actions

BRUCE D. GREENSHIELDS

*Dr. Greenshields is Assistant Director of the Transportation Institute; Lecturer in Transportation Engineering, Civil Engineering Department, and Lecturer in Engineering Mechanics at the University of Michigan. Previously he was Chief of the Highway Systems Branch, Office of the Chief of Transportation, Department of the Army. He was Professor of Civil Engineering at George Washington University from 1946 to 1956. His first job after being graduated from college in 1920 was as rodman with the Santa Fe Railway Company. Since 1922, he has been a teacher except for consulting work and leaves of absence spent in research. His contributions to the field of traffic engineering include: the photographic method of traffic analysis, 1933; application of the "random series" to the analysis of traffic behavior, 1936; co-authorship of the "Statistics with Applications to Highway Traffic Analyses," 1952; development of dimensionless index measure of quality of traffic flow, 1955.*

THIS reports on probably the first attempt to completely measure driving behavior and, at the same time, measure the environment of traffic and highway events that influence that behavior. The solution of any problem as broad and complicated as the safety and efficiency of highway transportation requires an *entireness* of data seldom achieved.

New methods for studying the relationship of traffic and highway events to driver-actions are employed in two related studies by the University of Michigan Transportation Institute.

Objectives of one, sponsored by the National Institutes of Health, are to: establish a yardstick or index to determine the degree of excellence of driving; make accurate measurements of driving behavior; and correlate driving behavior with the accident-experience of the driver.

The objective of the other study, sponsored by the Ford Motor Company Fund, is to develop a new method of studying driver-behavior and classifying drivers with consideration for the effects of the highway and traffic environment. Fletcher N. Platt, manager

of the traffic safety and highway improvement department of a major motor vehicle manufacturing corporation, is helping with the research.[1]

After presenting some background material, the field equipment and techniques of measurement will be described. This will be followed by an outline of the method of analyzing and interpreting the data. Possible applications will be mentioned.

## BACKGROUND INFORMATION

Attempts to measure the behavior of the driver on the highway go back more than a quarter-century. In 1933, the writer used time-lapse pictures to measure vehicle speed and spacing. As a more immediate forerunner of our present endeavor, let us begin with a study[2] conducted at the Yale Bureau of Highway Traffic in 1954. In this study, attempts were made to measure traffic stream-flow by means of a test-car equipped with a special recording speedometer that gave a continuous graphic chart of the varying speeds and a complete time-and-distance record. Using data collected with the special recording speedometer, it was possible to derive a characterizing number to describe the quality of traffic flow.

This number was equal to the average speed divided by the product of the change of speed multiplied by the square root of the number of changes. It became apparent during the 1954 study that a better quality index could be derived by including the change of direction per mile in radians. But obtaining the change in direction was not possible with the equipment then available.

From the fact that it was possible to measure and characterize the flow of a traffic stream, it was logical to conclude that it should be possible to measure and characterize the driving behavior of the individual driver who collectively makes up traffic stream-flow.

The concept that it should be possible to measure and evaluate individual driving patterns was supported by the findings of a later study. This study was conducted by the University of Michigan Transportation Institute in 1957 to find if there was a correlation

1. Mr. Platt is the author of "Operations Analysis of Traffic Safety," published in *International Road Safety and Traffic Review, World Touring and Automobile Organization, Traffic Safety Research Quarterly*, 1958 and 1960.

2. Bruce D. Greenshields, "Quality of Traffic Transmission," *Proceedings*, Highway Research Board, 1955, pp. 508–522.

between the "quality of traffic flow and the frequency of highway accidents."[3]

In this investigation, since the traffic flow was light, it was decided to pick vehicles at random as they approached the section of road chosen for test and then pace them over the section by following them with the test car. Only three roads were selected for study. Two were two-lane roads. The accident frequencies per million vehicle miles and the corresponding quality indices were as follows:

| *Road* | *Quality Index* | *Accidents Per Million Vehicle Miles* | *Single Vehicle Accidents Per Million Vehicle Miles* |
|---|---|---|---|
| A | 618 | 2.98 | 1.28 |
| B | 1023 | 1.03 | 0.36 |

This study showed a correlation between the way traffic moves and the frequency of accidents, and that it is possible to pace a driver and closely imitate his driving performance.

In the first part of the present N.I.H.-sponsored study, it was decided, in view of the findings mentioned, that it would be possible to select drivers at random, pace them over a selected section of roadway, obtain their accident records through their license numbers and direct inquiry, and then compare performances with accident frequencies and determine the relation, if any, between accidents and driving behavior.

The driving behavior patterns of more than 950 drivers were observed over the selected route of about five and a half miles in length. The behavior indices ranged from 0.5 to 20.

There were found to be serious defects in that method and it was abandoned. Too many drivers failed to remain on the selected route, even though it was chosen because of its few turn-offs. And there are apparently so few high-accident drivers in the average traffic stream that thousands of observations would have to be taken to obtain a sufficiently large sample of poor drivers.

Also, the route, selected partly because of its few turn-offs, did not have a large variety of highway and traffic conditions. Trial runs over a more varied and partly urban route yielded driving indices varying from 0.5 to over 900. Furthermore, the *following car* method is not as exact as having the subject-driver in the test car equipped with the driveometer.

3. Bruce D. Greenshields, "Traffic Accidents and The Quality of Traffic Flow," *Highway Research Board Bulletin 208*, 1958.

The selection of a new route with more and varying amounts of traffic meant that the recording apparatus should include a device for recording the changing traffic conditions. It could no longer be assumed that all drivers observed were driving in essentially the same environmental situations. The measuring device or devices would have to be designed to measure and record driving behavior and, at the same time, the traffic and highway events that influence driving behavior.

### DRIVEOMETER AND TRAFFIC EVENTS RECORDER

The measuring apparatus evolved to measure driving behavior and simultaneously record highway conditions is a unique combination of instruments. The recorder is shown in Figure 1, resting on a support on the rear seat. The mirror mounted on the rear of the front seat gives a rear view. See Figure 3 for mounting of camera. Figure 2 shows the attachment to the steering wheel and cables to speedometer, accelerometer, brake, switch and one to the cigar-lighter connection for current. The traffic events keyboard is shown on the seat beside the driver.

Instruments include these six: a speedometer with photocell relay to pick up speed changes; a take-off from steering wheel to give amount of turning; a gyro-compass with photocell relay to record accumulated direction change; a switch and counter arrangement to record number of times turning of steering wheel is reversed; a device to record the number of times the accelerator is depressed, and a recording camera focused on the speedometer and display panel of counters. The panel also includes a watch and a counter to record time.

The count is in seconds. Another counter, operating only when the car is moving, records the running time.

### CLASSIFICATION OF TRAFFIC AND HIGHWAY EVENTS

In addition, the display panel includes a set of counters to record traffic events. An observer riding in the car does this by operating switches on a keyboard. The manner of classifying the traffic and highway events will now be described.

All events may be classified as related or unrelated to the driving task. An unrelated event is defined as one that has no potential for

requiring the driver to change the motion of his car. An airplane in the sky might distract a driver, but there is no possibility that he would swerve to avoid it. A moving vehicle or an obstruction close to the roadway can cause a driver to change his speed or direction.

No attempt is made to classify events as hazardous or non-hazardous. An event not directly related to the driving task may distract the driver and cause an accident. In fact, the very lack of highway events can be dangerous by blunting the driver's alertness through monotony.

Traffic and highway events, whether related or unrelated to the driving task, fall into two general classifications: fixed and variable. The fixed events include all stationary highway and environmental features such as curbs, signs, stop lights, trees, and buildings. The variable events include all vehicles and pedestrians, whether moving, standing, or parked. A parked car may suddenly become a moving car. All events, both fixed and variable, are dynamic with respect to a driver in a moving vehicle.

For statistical analysis, all traffic and highway events should be counted. It is desirable, if possible, to include both variable and fixed events in one grouping. The number of events may be recorded by unit of space or unit of time. The driver perceives the number of events in his visual field and requires a certain amount of time to respond to the events he sees. Time is made up of the psychological processes of perception, intellection, emotion, and volition. This time factor is universally recognized, and drivers are required to drive slower in urban areas where the density of traffic and highway events is greater than in rural areas.

As the driver moves over the highway, the number of events he sees varies from instant to instant. The camera may be used for recording the changing scene. As the illustrative picture shows, the camera is arranged to give both front and back view by means of a mirror.

## DENSITY OF EVENTS

A picture of a highway constitutes an instantaneous record of events. The number of events in each picture may be thought of as the instantaneous density of events for the visible space included in the picture.

Figure 1 is a view showing the "driveometer and traffic events recorder." Mirror mounted on rear of front seat provides a rear view as well as a front view for camera placed on back of rear seat. (See Figure 3.)

Figure 3 shows a 16 mm. Bell and Howell camera mounted in back of the rear seat. This camera is connected to a timing device and has an electric release so that time-lapse pictures may be taken at either a one or two-second interval.

Figure 2 shows attachments to steering wheel, accelerator pedal, speedometer, and cigar lighter socket (for electrical power). The box resting on the seat beside the driver is the traffic events tabulator.

If the pictures are taken at sufficiently short intervals of time, a continuous average space or perceptual density is obtained, regardless of the speed at which the test car containing the camera is moving. Statistical sampling methods have been used to determine the proper interval of time between pictures. A two-second interval has been found short enough to give, in effect, a continuous record. In counting the events, it has been judged best to put them into categories rather than to count single objects. "Cars parked on the right," for example, is a single event even though there may be several cars. One or several vehicles approaching from the right is counted as one event, etc. Events are counted on a sampling basis.

Since transcribing the data from the pictures is time-consuming, a "traffic events tabulator," as mentioned above, was constructed. This tabulator furnishes a digital record of the number of events.

### USE OF TRAFFIC EVENTS RECORDER

In the use of the traffic events tabulator, an observer sitting in the front seat beside the driver holds in his hand a small flat box on which is mounted a panel of switch buttons. The switches are coded for various traffic events. The observer pushes the switches to the *on* or the *off* position as the car moves and the traffic conditions change.

The switches are coded largely by their positions on the panel. A symbol near the center of the board indicates the position of the test vehicle. The switch directly above the symbol represents a vehicle in front of the car. As soon as the observer sees that there is a vehicle ahead, he pushes this switch to the *on* position and leaves it there until the vehicle is no longer in front of the test car. If there are two cars ahead, another switch designated as *C* is switched to the *on* position. Other switches, *A* to *N*, are coded for other traffic situations such as *car passing on left*, *car passing on right*, *parking on left*, etc. As noted, a *group* of objects may be counted as one event. It is assumed that the driver simply scans a group of cars, rather than noting each one. One or several pedestrians approaching on a crosswalk from the right is counted as one event. By using more counters and two observers, more refinement could be obtained, but this has not proved necessary.

Having tabulated the number of traffic and highway events

present in the visual field at any instant of time, it is possible to derive an events density index. Since the driver must respond to his dynamic environment within certain limits of time, in deriving an events density index, we are interested in determining the relative amount of time a driver has to respond to highway and traffic events as he travels over different routes.

### TRAFFIC DENSITY INDEX

The amount of time a driver has to adjust himself to his dynamic environment depends on the number of events in his perceptual space-field and the rate at which the field is changing.

If it is assumed that the space-field is practically constant in width, its rate of change is proportional to the speed. This means that a driver traveling at sixty miles an hour has half as much time to respond as he would at thirty miles an hour.

Clearly, the relative amount of time available for driver-response depends on the density of events in his perceptual field and the speed at which he is traveling. The higher the density and the higher the speed, the less time the driver has to respond to the traffic and highway events in his environment. This relationship expressed as an events-density index would equal the product of the speed and the density of events in the perceptual field.

The principal objection to the index mentioned is that it does not take into account the depth of the perceptual field.

### EXTENT OF THE PERCEPTUAL FIELD

The number of environmental events that are affecting the driver depends on the extent of his sensory field, as measured by both distance and time. No accurate measurements of the extent of this zone on influence have been made and perhaps none is possible, but some related measurements have been made from which it is possible to make a rough estimate of the time and distance at which events begin to affect driver actions.

One measurement is that of the distance from the driver to the area on which he focuses his attention as his speed increases. One reference[4] states that the average distance of the focal point in-

4. Matson, Smith & Hurd, *Traffic Engineering* (McGraw-Hill Book Company, 1955), p. 17, referring to J. R. Hamilton and L. L. Thurstone, *Safe Driving* (New York: Doubleday & Co., Inc., 1937), p. 10.

creases in a straight-line relationship with the speed, being about 500 feet at twenty miles an hour and 1,800 feet at sixty miles an hour. In time, these distances amount to about seventeen seconds and twenty seconds.

In a study[5] in Ohio in 1935, it was found that the mean point at which a driver adjusts his speeds to that of the vehicle ahead is at about 4.5 seconds. The adjustment begins before this, at about nine or ten seconds.

In the Ohio study, it was also found that, on the average, a driver required a time-space of nine to ten seconds to pass. More recent studies give similar results.

In a later study[6] conducted at the Yale Bureau of Highway Traffic, it was found that drivers at a stop sign required, on the average, a six-second gap between vehicles in the opposing traffic stream to proceed in crossing.

On city streets, traffic events may not be visible until they are within a few seconds of the driver. From this and the examples just mentioned, it may be judged that the time-distance at which events commence to influence the driver may vary from twenty seconds or more on an open highway to as little as two or three seconds on a city street.

### ESTIMATING PERCEPTUAL FIELD DEPTH

A simple method of estimating the focal depth of a field is to note the point ahead on which the eyes are focused and then measure the distance to that point by reading the odometer. An odometer reading to 1/100 mile is needed. An observer does the recording and the reading of the odometer and the speedometer. Several trips over a route should give a close estimate of the average depth of focus. A series of runs gave results similar to those obtained by Hamilton and Thurstone (cited); namely, 510 feet at twenty miles an hour and 1,600 feet at sixty miles an hour.

The task of classifying driving events and of defining the limits of the zone of influence may be simplified if it is kept in mind that

5. Bruce D. Greenshields, "Initial Traffic Interference," presented for discussion at the 16th Annual Meeting of the Highway Research Board, 1936.

6. Bruce D. Greenshields, Donald Schapiro, and Elroy L. Erickson, "Traffic Performance at Urban Street Intersections" (Yale Bureau of Highway Traffic, 1947), pp. 69–71.

one driving experience under one set of events is to be compared with another driving experience under another set of events. If the events in both cases are recorded in the same manner and with the same degree of precision, significant differences in the two sets should be detected.

Having determined the length of the visual field (a close approximation seems to be satisfactory), the density index may be expressed as:

$$E = \frac{P \times S}{D}$$

wherein E = events index, P = perceptual density (number of events in visual field), S = speed, and D = depth of perceptual or space field.

The use of the events index may be illustrated by an example. Let it be required to determine the relative density of events on two routes for which the following data have been collected.

For route A, the average space density of traffic and highway events is seven and for route B, ten. From field observations, the average depth of the field for route A, which is semi-rural, has been estimated to be 1,000 feet. The depth for B is estimated at 500 feet. If route A is traveled at fifty miles an hour and route B at twenty-five miles an hour, what is the relative density of events?

For route A, the events index is equal to:

$$E = \frac{7 \times 50}{1000} = .75;$$

for route B, the index is equal to:

$$E = \frac{10 \times 25}{500} = .5.$$

The relative amount of time the drivers have to respond to traffic and highway events is equal to:

$$\frac{.50}{.75} = \frac{2}{3}.$$

This means that on route A the driver traveling at the assigned speed would have two-thirds as much time to adjust to traffic and highway conditions as on route B.

For equal speeds, the ratio would equal:

$$\frac{7}{1000} \div \frac{10}{500} = \frac{3.5}{10} = .35.$$

Analysis of data to date has been confined to that necessary to verify procedures and indicate trends. Most of the data collected have not been analyzed and more are being gathered. The establishment of standards of driving performance will require the collection and analysis of a large amount of data, but preliminary findings give assurance that *high-accident* drivers have different driving patterns from the *low-accident* drivers.

From this, it follows that proper driver training should improve the poor driver. (The *italics* indicate that there is no generally accepted definition of *good* and *poor* drivers.)

A comparison of high school and beginning drivers with *average* drivers shows that the driving habits of young drivers differ from those of more experienced drivers. Assuming that the more experienced driver, on the average, is a better driver than the inexperienced, the driveometer could be used to check the driving behavior of the inexperienced driver and determine the progress of his training program The patterns of the *good* driver would be used to establish driving standards.

## DRIVER TRAINING

Let us turn to the question of the possible use of the driveometer in driver training. The suggested procedure would include: the selection of a test route including a variety of driving conditions; the establishment of a standard of performance by having skilled drivers traverse the course under varying traffic conditions, and the testing of the driver trainees over the course.

Successive trips over the test route would show the rate of learning as well as the degree of skill attained. The objective measurement furnished by the driveometer would not replace the subjective judgment of the teacher, but it is considered to be more reliable.

The fact that the driveometer furnishes an integrated measure of driving performance over a course of considerable length (ten miles or more is the present estimate of length needed) suggests a new approach to the driving simulation problem.

## A SIMULATOR FOR DRIVER TRAINING

The problem of driving simulation is simplified if limited to the task of simulating driver-actions rather than reproducing driving environments. The simulation of driver-environment to the point

of seeming reality is costly—perhaps a million dollars or more a unit.

The construction of a device to cause the driver to go through the same sequence of driving operations he would cover in driving over a highway should not be very expensive.

The idea of simple driving simulators dates from about thirty years. In 1934, the writer, in co-operation with Prof. R. S. Swinton of the University of Michigan, worked out the details of a driving simulator in which the driver would redrive a motion picture of a highway. That is, using the vehicle driver-controls, the driver could change the speed of the picture or turn it from side to side.

The time and correctness of the driver-response was determined through a photocell pickup and chronoscope. It was estimated that staging and photographing emergency highway situations that would arouse "emotionally" influenced actions would be quite costly. The driver simulator itself would not be very costly. There was little interest in such a device at that time, and nothing was done about it.

It may be asked why, if simplified simulators are already available, it is necessary to develop a new one. The answer lies in the manner in which the driving simulator is to be used. It would be used to furnish a sequence of stimuli to obtain a desired driving pattern, rather than single responses. This concept may be made clearer by an illustration.

Suppose it is desired to make a laboratory check of the driving performance of a beginning driver against the performance of an experienced driver. First, the driving pattern of the experienced driver would be measured and recorded over a selected section of highway. The next step would be to obtain the same pattern in the *laboratory* with the same experienced driver. This would involve varying the stimuli until the desired pattern was obtained.

Responding to the same stimuli, the beginning driver's record would be compared with that of the established standard. It will be recalled that the driveometer furnishes an integrated record in numbers. The driving simulator would, obviously, be designed to furnish a similar record. Using this procedure, a file of driver training "stimuli and response" records could be built up.

In the proposed approach to the problem of driver-training, the emphasis is on the performance pattern over a route of consider-

able length, and not on single maneuvers. It might be likened to judging a golf player by how he makes one shot and by his score over the eighteen-hole course. The over-all score more reliably measures his skill.

### EVALUATING THE STREAM FLOW

The aggregate of the skills of the driver in a traffic stream largely determines the efficiency and safety of the stream flow. The other major factor affecting stream-flow is the highway environment. Some highways are much more dangerous than others. Despite the high average speeds, the limited-access expressway is about three times safer per mile of travel than the average road.

Since the purpose of a street or highway is to move traffic rapidly and safely, it is surprising that we have no generally accepted method of measuring the way vehicles move over a highway. The quality of traffic transmission is a fundamental factor in transportation (See reference 2, page 665).

Use of a successful method of evaluating traffic stream flow would make it possible to detect traffic flows that are dangerous and expensive in time-loss and vehicle operating costs. Poor traffic flow results from poor or inadequate highway construction and control devices. The driveometer and traffic events recorder furnishes a measure of traffic flow easily and quickly obtained in digital form so it can be interpreted with little effort.

Limited experience in measuring the quality of stream-flow indicates it is far easier to measure the differences between two stream-flows than between the performances of two drivers. Each stream-flow is composed of individual drivers, so that the individual driver differences "cancel out" in comparing two flows.

### EFFECT OF HIGHWAY DESIGN AND CONTROL DEVICES ON TRAFFIC FLOW

Standards of traffic stream-flow need to be established and correlated with safety and highway conditions. The driveometer furnishes a more accurate, complete, and easy-to-use measure of traffic flow than heretofore available.

Along with a study of traffic flows, there should be a study of highway features and traffic-control devices that cause a traffic

stream to flow smoothly and safely—or erratically and dangerously. In other words, both cause and effect should be studied.

One might compare traffic flow to water flow. Both turbulent and smooth flows of water have been studied. If we know the type of *water* pipe, it is possible to estimate the kind of flow that will take place. If we knew more about the interrelationship of the quality of *traffic-stream* flow and the characteristics of highways and the frequency of traffic accidents, we could build safer and more efficient highways.

### VEHICLE DESIGN AND DRIVING PERFORMANCE

It is logical to suspect that the type of driving controls such as *standard*, *power*, etc., has a lot to do with driving behavior. Does the stick-control enable the skilled driver to give a better performance? Does the same hold true for the less skilled driver? How important is "easy to handle?" Should we have *finger* brakes?

It is believed that the driveometer should make it possible to test the drive-ability of the vehicle as well as the skill of the driver.

### SIGNIFICANCE OF THIS RESEARCH

It is believed that the new methods and techniques described will have broad significance in highway transportation. They should help to provide:

A better understanding and definition of the driving task.

Parameters for comparison of "real life" driving behavior to simulated conditions.

More knowledge of the effect of environment on driver-actions.

Data on the relationship of driver-actions to various traffic densities.

Information on the effect of different kinds of vehicles and vehicle equipment on driver-actions.

New driver-training aids and techniques.

Further tests planned for obtaining statistical reliability of the data and measuring the range of driver's behavior under normal and some abnormal conditions should provide information that will be useful in developing a complete mathematical model of the driving task and a fundamental system for evaluating drivers, vehicles, and highways.

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